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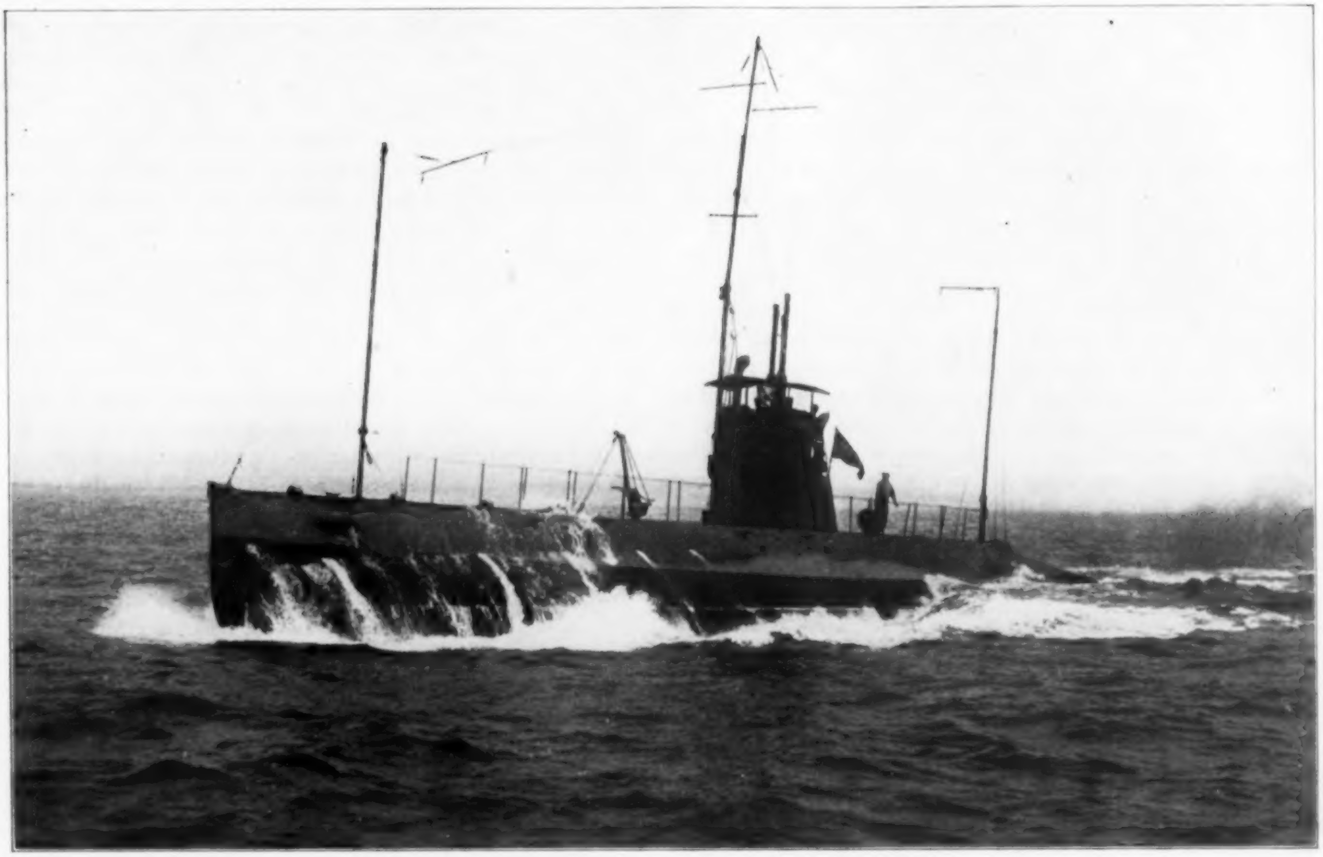

U. S. SUBMARINE *K-1,* JUST EMERGED. THE WIRELESS IS LOWERED FOR SUBMERGED WORK

THE SUBMARINE

By C. H. BEDELL,[1] GROTON, CONN.

RECENT events have forcibly brought to the attention of the entire world the capabilities of the little boat known as the submarine. All the characteristics of these boats are fascinating; to the engineer on account of the many unique problems that have to be solved; to all of us on account of the many dramatic possibilities in connection with submarine navigation. Since these dramatic possibilities are so great in number, it is surprising that our popular fiction writers have not made more extended use of the submarine. Probably this neglect of such a promising field has been due to lack of the necessary engineering knowledge to handle the subject properly. We have, however, one book on the submarine in the field of fiction that is well written and full of interesting scientific and engineering material. This book is Jules Verne's Twenty Thousand Leagues Under the Sea. I read it as a boy, when it was first published in about 1874, and was fascinated by the picture it gave of life beneath the wave, not imagining that it would ever be my privilege to journey thus in those depths of which we know so little. A short time ago I reread the book, and was again fascinated by it, because it gave me a chance to see how closely we have lived up to that imaginary picture of Jules Verne.

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As far as the handling of a submarine is concerned, whether under way, on the surface or submerged, or at rest on the surface, poised at any depth or resting on the bottom, the boats of the present day are as perfect as the *Nautilus* of Jules Verne. We may even, if we so desire, make our boat so that, when it is at rest submerged, a man with a diving helmet, and entirely disconnected from the submarine or the surface, may pass from it into the sea and explore the ocean floor for an hour or more, as Captain Nemo of the *Nautilus* did. That such construction is not used is due to the fact that there seems to be no material need for such operations. The *Nautilus* was driven by electricity. We also use electricity when running submerged, but we obtain our electricity from storage batteries, while Captain Nemo obtained his in some mysterious way from the sea itself. The great difference between fiction and reality in this case is that the *Nautilus* was able to go around the world with one supply of energy, while we are obliged to come to the surface after one or two hundred miles for the purpose of recharging our storage batteries.

The men on the *Nautilus* are supposed to have been able to see objects at distances up to one-half or three-quarters of a mile by the light of the sun or by powerful electric lamps. While we at this time probably have more powerful electric lamps, it is impossible for us to see any great distance through water, no matter what method of lighting is used. This is true, at least, along our shores as far out as the Gulf Stream.

An enormous amount of sediment is continually being poured into the sea by our rivers and streams, and in addition the endless wash of the waves on our sandy shores constantly tends to maintain the turbidity of the water. I have frequently looked through the periscope of a submarine when resting on the bottom at a depth of 50 ft. The second periscope, some five or six feet away, could easily be seen, but the bow of the boat, 75 ft. away, could not be seen. The suspended matter in the water acts exactly as does fog in the air in preventing distant vision. On account of this fact, all running when totally submerged must be by distance runs, obtained by known speed and time. Of course, in certain waters the limit of vision may be materially increased, as, for example, among the islands of the West Indies or off the coast of Southern California, yet even in such waters it is not probable that one could see more than 100 or 200 ft., and such a distance is not sufficient for purposes of navigation. Thus at one stroke we take away the greatest factor that gives such a charm to Verne's work—the major portion of the control of the submarine must be by vision above the waves.

Another point interesting to consider is that of the pressure per square inch at different depths, for in this connection Jules Verne materially slipped up in his calculations. He tells about Captain Nemo forcing his boat to depths of 6000 or 7000 ft., not realizing that pressures increase nearly half a pound per square inch for each added foot of depth. At 6000 ft. the pressure is nearly 3000 lb. per sq. in., and the *Nautilus*, as described in Verne's work, would not have stood any such pressure. An illustration in the book shows a man seated before a large plate-glass window, and another man swimming in the water outside. This window must have been at least 25 ft. square, and at a depth of 200 ft. it would have to sustain a pressure of about 100 lb. per sq. in., or 175 tons on the window. At 6000 ft. the total pressure would be 5250 tons. Certainly no glass made of the form illustrated could sustain such a load. However, it makes a very pretty picture.

Another point shows Verne's misunderstanding. He states that they had to use all the enormous power of her engines to force the boat down against the great water pressure; the greater the pressure, the greater power it took. This is not according to fact, for if a body is once made heavier than sea water and starts to sink, it will continue until the bottom is reached, if the salt in the sea water remains a constant percentage, a condition which practically exists in the open sea. The question is frequently raised in our newspapers whether a ship sunk by collision or the like will sink to the bottom or go a certain distance and then remain poised. The question was raised at the time the *Titanic* was sunk. The solution of the question rests upon the compressibility of the material of the ship as compared with that of water. If the latter is greater than the former, and the depth is great enough, a point would be reached where the water would be as dense as the material of the ship, and there the ship would remain poised. For the purpose of calculation, let us take the extreme case of a solid steel ball dropped overboard in the open sea. Now, in general, we say that water is incompressible. This statement arose in comparing the compressibility of water with that of a gas, such as steam. When an engineer allows water to get from his boiler into his engine cylinder, and the piston striking this water on the return stroke drives off the cylinder head, he says the water is incompressible. As compared to a gas it is incompressible, but as compared to steel it is compressible; indeed, it is more compressible than steel. Therefore, our steel ball as it descends into the sea and is compressed has water around it that is being compressed at a more rapid rate under the increase of pressure than the steel is. If the depth, and therefore the pressure, is great enough, a point will be reached where the water will be as dense as the steel, and at that point the ball will remain suspended. A calculation based on the compressibility of steel and water shows that the required depth is about 100 miles. As the sea is only some five or six miles deep, it is evident that our steel ball will go to the bottom. Now let us take the case of the ship that has been sunk. When she starts to go down she is heavier than the water around her. The ship, as a whole, is far more compressible than the steel of our ball, and will get relatively heavier as she descends, that is, will sink faster and faster until the bottom is reached. Returning now to the submarine, where we have a hull that is perfectly water-tight. Since this hull is composed of circular frames on which is mounted the hull plating, its compressibility is far greater than our steel ball; indeed, it is far greater than water. In consequence, if a submarine is so trimmed down that she is even slightly heavier than water, she will sink to the bottom. This has been conclusively proved in connection with our tests of submarines at 200 ft. Every submarine for the U. S. Government must be taken down to this depth and kept there for ten minutes. In making this test, it is the custom first to anchor the boat where the depth of the water is right, then trim the boat by admitting water into her tanks, trimming her down until she has only a few hundred pounds' buoyancy, then hauling in on the anchor rope. This operation draws the boat down until the desired depth is reached. In one or two cases, in the trimming-down operation, but a small amount of reserved buoyancy was given the boat, and as the boat descended and became compressed this reserved buoyancy was lost and the boat went the rest of the way to the bottom. From the above it will be readily seen that Verne's statement that it took all the power of the engines of the *Nautilus* to drive her into those great depths is not correct. There is one exception to the general statement that a body starting to sink will go to the bottom, and this is where the water is stratified, when large quantities of fresh water from rivers come in contact with the salt sea water. Such a condition exists in the St. Lawrence. Recently in making the 200-ft. depth test in those waters it was found necessary to add 5000 lb. to the water in the tanks after the boat had started to sink in order to get her down to 200 ft. This was due to the fresh water from the river being over the heavier salt sea water.

THE SUBMARINE IN HISTORY

The history of the submarine extends over quite a period of time, as there is a record of such a boat having been built about the year 1624. During the next 150 years the subject was frequently considered by marine engineers, but no construction was undertaken. At the time of our Revolutionary War, the interest in the subject was transferred from Europe to this country, due to the fact that a small submarine had been built by David Bushnell, of Connecticut. This boat was only large enough for one man and shaped like a flattened egg, with its major axis vertical. It was fitted with tanks and pumps, anchor operated from the inside of the boat, screw propeller in the front of the boat, another screw propeller at the top with its axis vertical, rudder and torpedo at the stern, and at the top of the boat a screw operated from within the boat. It is evident that this screw was intended to be worked into the planking of a ship at anchor. The torpedo was fastened to the screw by a line, and when the submarine was moved away the torpedo remained with the screw. The sep-

arating of the torpedo from the submarine started a clock, which in a certain time would explode the torpedo. Bushnell had to educate the public on two points in connection with his boat, the exploding of gunpowder under water and the use of the screw propeller. The propeller had been invented a short time before by another man, but evidently Bushnell's boat was the first on which it was used. During the Revolutionary War a chance at last came to make use of the boat, against a British war ship anchored off Governors Island. Unfortunately, the man who had been conducting the operations of the boat was sick at the time and another had to take his place. Floating down with the tide in the late hours of the night, the submarine was maneuvered until she came under the war ship. The operator in attempting to force the screw into the planking of the ship failed on account of striking metal fittings. Before he could relocate his boat the tide carried him away and he had to give up the attempt. Two other attempts were made against British ships anchored in the Hudson, but these also failed on account of the strong tide. If the anchor of the submarine had been used until the torpedo was attached to the ship, the attempt would have been successful. Public opinion did not support Bushnell in his work, and therefore nothing further was done.

The next submarine of interest is that of Robert Fulton, who launched the *Nautilus* in the Seine in 1801. He conducted many experiments with this boat, but not getting the necessary financial support in France, took the boat over to England. There he created quite a furor, and many experiments were conducted, even going so far as to the blowing up of an old hulk provided for the purpose. The people did not consider the time ripe for that method of warfare, and Fulton again failed to get support. He then came over to this country and succeeded in obtaining a grant of $50,000 from Congress for the conducting of experiments. It is understood that it was Fulton's submarine that was to make an attack on a British prison ship off New London, but the commander of the prison ship hid behind his prisoners and obtained the influence of their friends on shore to prevent the attack. The work with Fulton's submarine was discontinued, as again it seemed that popular opinion was not ready for the use of such ships.

The credit for the first actual service of a submarine in time of war will have to be given to a boat built by Wilhelm Bauer, a Bavarian, who built one such boat for Germany and one for Russia. The boat built for Germany succeeded in breaking up the blockade of the Danish fleet off Kiel. Later, this boat was sunk, due to the collapse of her hull from excessive water pressure, the crew luckily escaping. A few years ago the boat was located during certain dredging operations, was raised, and is now on exhibition in Berlin.

During our Civil War the South became quite interested in the submarine, and several of the boats, called "Davids," were built. These, as were the earlier boats, were all operated by man power, eight men being used to drive the propeller. Many accidents were experienced during the experiments on these boats and several crews were lost. These accidents, however, did not occur when the boats were operating submerged but when on the surface. The small conning tower used was very low, and waves from passing steamers and the like washed over it, causing the boat to sink. New crews were quickly found and experiments continued. At last a chance to use the boat came, and an attack was made on the U. S. frigate *Housatonic*, anchored off Charleston. The attack was made at night, and therefore the boat was operated on the surface only. A spar torpedo was used, as at that time the automobile torpedo had not been developed. It is reported that an officer on the deck of the *Housatonic* saw the submarine approaching the ship, but thought it was a plank floating with the tide. This idea was quickly dispelled, for after a terrific explosion the men who had been on deck found themselves in the water. The *Housatonic* was sunk, and carried down with her the submarine and all her brave crew. It is probable that the smaller boat was sucked into the hole in the larger ship, and held there by the water pressure.

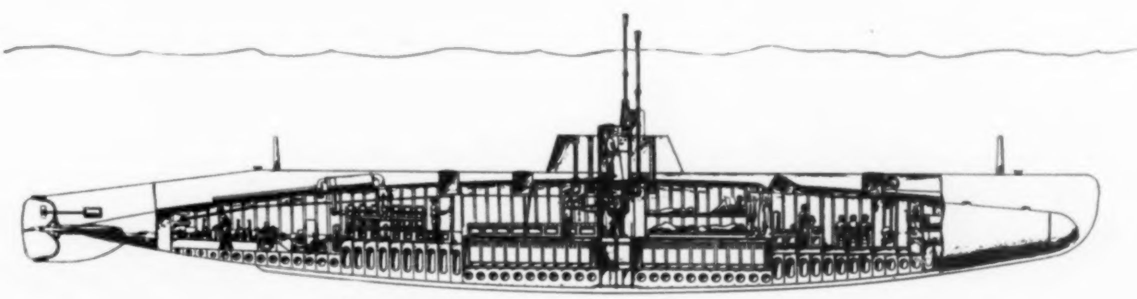


Fig. 1 Cross-Section of a Modern Submarine

Present-Day Submarines

During the following twenty-five years many submarines were designed and a few built. None of these, however, proved to be successful. I am going, therefore, to jump to the time of John P. Holland, and describe the submarine of the present day. Holland was an Irishman who came to this country just before the Civil War, a man of but very little education but of bright mind. He was much interested in the fight between the *Monitor* and the *Merrimac*, and soon commenced to consider submarine work. At last he succeeded in getting support for his experiments and built two or three small submarines. His idea being to build a boat that would sink the British Navy, his trend of mind is shown by the name he gave one of his boats, the *Finian Ram*. His first boats did not amount to much, but he acquired a great deal of experience, discovered what to do and what to avoid, and was then in shape to attempt more extended work. It was at this time that he joined forces with the Electric Boat Company, and the *Holland* was their first product.

Mr. Holland started his work at just the right time, for the internal-combustion gasoline engine giving large power with small space and weight had just been developed and large storage batteries with corresponding electric motors

were to be had. Without this material it is safe to say the submarine would still be in an experimental form.

The general arrangement of the modern submarine follows very closely the design given in sketch form in Fig. 1. The hull proper is cigar-shaped, since this form is best suited to withstand the pressure of submergence. Above the main hull is a narrow superstructure extending from the bow nearly to the stern. This superstructure may be watertight, but in general is open to the sea. It serves to house certain external fittings, and forms a deck for the use of the crew. At the bow just within the bow casting is the bow cap, covering the outer ends of four torpedo tubes; two openings are made through this bow cap, and by rotating the cap the openings may be placed in line with the different torpedo tubes. These tubes at the inboard end are fitted with doors, so that after the tubes have had the water drained into the

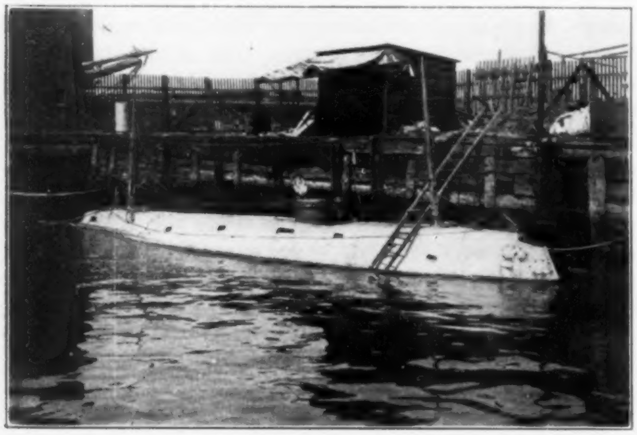


FIG. 2 U. S. SUBMARINE *Holland*

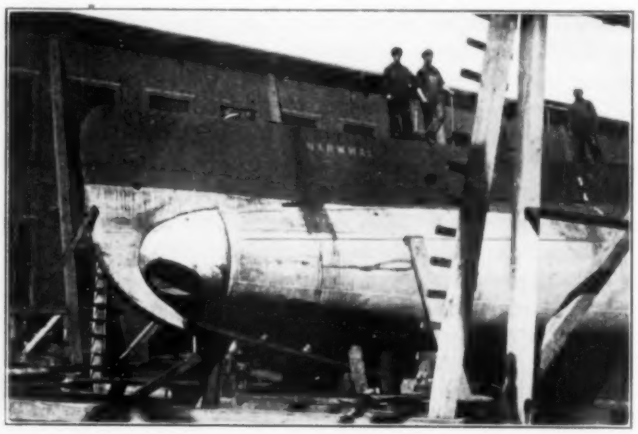


FIG. 5 BOW OF SUBMARINE WITH BOW CAP IN POSITION FOR TORPEDO FIRING

FIG. 3 U. S. SUBMARINE *M-1*

FIG. 6 STERN OF A SUBMARINE

FIG. 4 LAUNCHING A SUBMARINE

FIG. 7 TAKING A TORPEDO ON BOARD

trimming tank which surrounds them, the doors may be opened for the admission of spare torpedoes. Immediately abaft the tubes is space for spare torpedoes, and below the deck, tanks for fuel. In the design shown, the galley is also located in the compartment. In the central part of the boat is the main operating compartment, in which are the levers that control the main ballast, auxiliary ballast, and adjusting tanks, steering and diving wheels, control of all high-pressure air lines, periscope and connection to the conning tower. In the two compartments ahead and abaft the central operating compartment are placed the two sections of the storage battery, these batteries being large enough to supply current to the main motors and drive the boat for one hour at 11½ knots, or at low speed to give her a radius of about 100 miles. Around the storage battery are the main ballast tanks. It is in connection with the tanks of a submarine that Mr. Holland showed his genius, and no submarine can be considered a success that does not follow the lines of tank construction that he prescribed. In all the earlier submarines the tanks were constructed large enough to take the maximum amount of water that might be required, and therefore were almost never totally filled. In consequence, as the angle of the boat changed, the water was free to flow from one end of the tank to the other, making it almost impossible to keep the boat properly trimmed. Holland, realizing the condition made it a rule that the main ballast tanks should be of such a capacity that when entirely filled the boat would be brought to the awash condition only, and that the final adjusting of the buoyancy of the boat must be made by the use of a small tank which would have but a small free-water surface if not entirely filled. The main ballast tanks are therefore entirely empty or completely filled. Abaft the storage-battery compartment are the engines, main motors, pumps, air compressors, and at the stern are the after-trimming tank, twin-screw propellers and the steering and diving rudders. The conning tower is placed over the central operating compartment and in the sketch shown is fitted with one of the periscopes. Steering is done by means of an electric motor controlled by push buttons.

The operation of a boat submerged is quite different from one on the surface. On the surface if a man walks from amidships to the bow, the bow will be depressed, displacing a greater amount of water, and therefore able to sustain the increased weight. When the boat is submerged no change of displacement can occur, and consequently such shifting of weight will cause the boat to take a greater angle. A boat submerged may be likened to a pendulum having a length equal to the distance between the center of buoyancy of the boat, and its center of gravity, generally a distance of about sixteen inches, and the weight of the pendulum being the weight of the boat, say 500 tons. A weight moved from amidships to one end of the boat would produce a leverage to swing this pendulum from the vertical, in other words, to cause the boat to take an angle by the bow or stern. As a submarine when submerged will go the way she is pointed, it will readily be seen that change of angle will cause her to change her depth. The man at the diving wheel not only has his wheel and depth gage before him, but also a clinometer, a sort of level by which he can tell the exact angle of the ship and therefore tell whether the boat will change her depth or not as she goes along. As a matter of fact, the boat is swinging up or down most of the time, and it is the duty of the man at the diving wheel to check these motions and control the boat so that she will remain at the depth

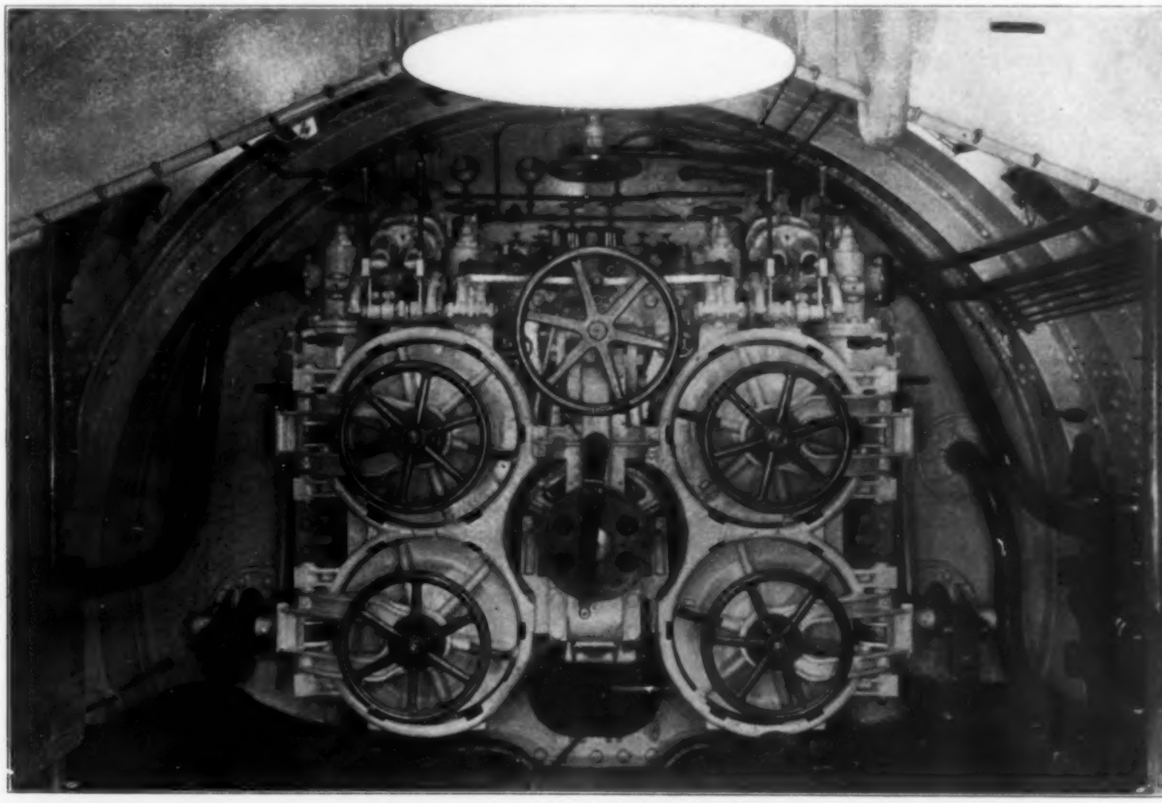


Fig. 8 Inner Ends of the Four Torpedo Tubes

desired. It is a duty requiring constant attention, and the man at the diving wheel can perform no other duty. In the

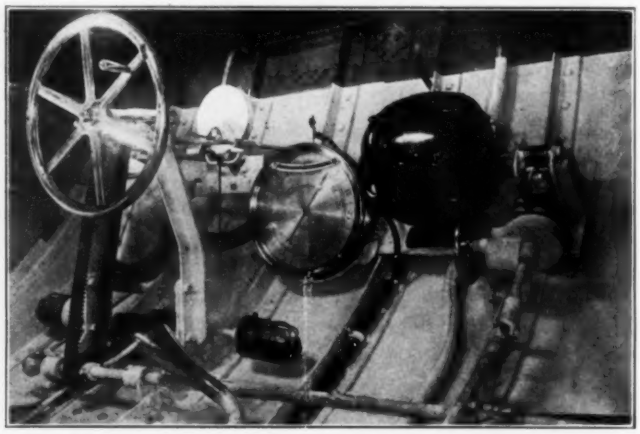


FIG. 9 DIVING CONTROL STATION

small boats first built, great care was exercised that there should be no shifting of weight when the boat was running submerged. In the large boats as now built the weight of a man is such a small percentage of the total weight that

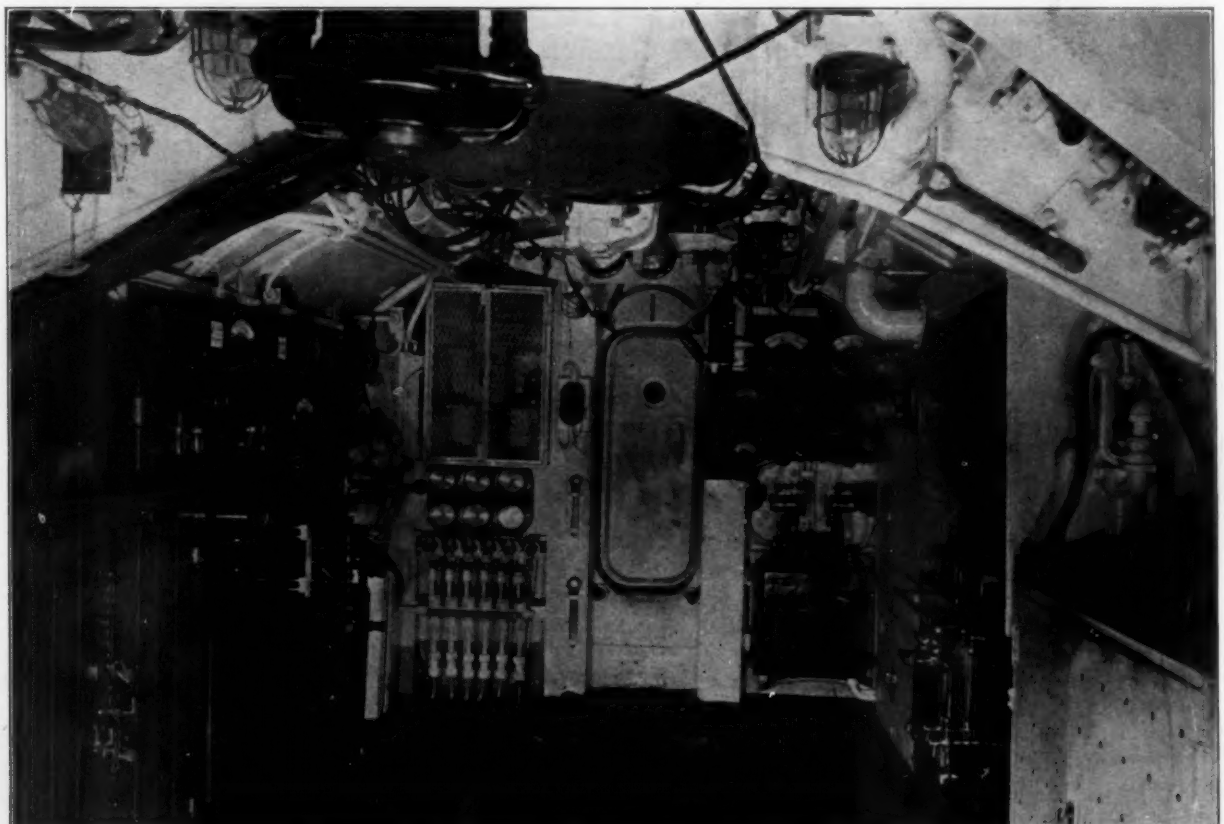


FIG. 11 AFTER END OF CENTRAL OPERATING COMPARTMENT

the ordinary movements of the crew may be counteracted by the man at the diving wheel.

EQUIPMENT OF SUBMARINES

From the *Holland* (see Fig. 2) having a length of about 53 ft. to the *M-1* (Fig. 3) with a length about 200 ft. is quite a change, yet a torpedo from a small boat, if it reaches its mark, is as effective as one from a large boat. It is the fact just mentioned that indicates why a submarine will

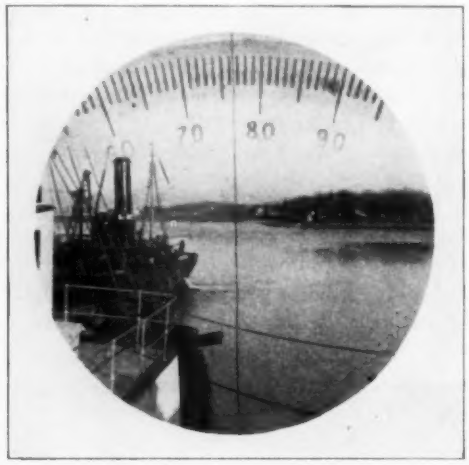


FIG. 10 VIEW TAKEN THROUGH PERISCOPE

retain her usefulness until she is literally worn out. She does not become obsolete as does a battleship as soon as a more powerful ship is constructed. The little *Holland* was thus in commission until worn out. Every other submarine built for the U. S. Government is in active service.

At the time the *Holland* was built we had no periscopes. In consequence, the boat had to be handled by "porpoising," that is, running a short distance submerged and then coming to the surface far enough to expose the conning tower, thus

getting a chance for a look around, and then diving. This porpoising can be done very quickly; the boat can pass from the depth of 30 ft. to the surface, line up on the target, have the torpedo fired, and be again below, all in 30 seconds. The advent of the periscope greatly aided submerged navigation, since at all times vision may be had without exposing the hull to the danger of a chance shot. The increased size of the boats has made them far more comfortable, and better sea boats (compare the freeboard of the *Holland* with that of the *M-1*), and better adapted for long service at sea. The development of wireless telegraphy now permits the submarine to keep in touch with the shore, and all submarines are now equipped with this wonderful apparatus, the tall masts required being so constructed that they may be quickly lowered for submerged work.

In the design of a submarine a far greater amount of preliminary work in the line of calculating of weights, disposal of equipment, etc., has to be done than with a surface boat, for not only is there a double motive-power equipment, but the boat must be designed for both surface and submerged work, with all the complicated control apparatus required. Some idea of this construction may be obtained from the illustrations given. Fig. 4 shows the launching of a submarine, the cigar shape of the main hull being of sufficient strength to withstand the pressure of 200 ft. submergence, that is, nearly 100 lb. per sq. in. Fig. 5 represents the bow of a submarine before launching; it shows the bow cap with opening in line with the torpedo tube. When it is desired to close the tubes, the openings of the bow cap are placed under the bow casting. In Fig. 6 we have the stern of a submarine. In addition to the twin screws and steering rudder as used on a surface boat, the submarine has the horizontal diving rudder for steering the boat in the vertical plane. Each submarine can carry at least eight torpedoes. Fig. 7 shows the taking of a torpedo on board, and Fig. 8 shows the inner ends of the four torpedo tubes and escape hatch.

A view of the diving station showing diving wheel and depth gages is given in Fig. 9. On the depth gage below the pointer is shown the curved glass tube of the clinometer. Fig. 10 reproduces a view taken through a periscope. The vertical line is the cross-wire and shows the exact direction the periscope is pointed. The scale at the top is a portion of the card of the periscope and shows that the periscope was pointed 76½ degrees from the north towards the east. The after end of the central operating compartment is shown in Fig. 11. This particular boat had an unusually large central operating compartment, at least four times as large as is usually constructed. The dark object at the top of the picture is the lower end of one of the periscopes. Behind this is an escape hatch, the ladder to it having been removed so as not to obstruct the view from the camera. In the left lower corner is the ice box, then comes the battery and auxiliary switchboards. In the center of the picture is the closed door leading into the engine room. To the right of the door is the control equipment of the two main motors and on the right are the electric cooking range and galley sink.

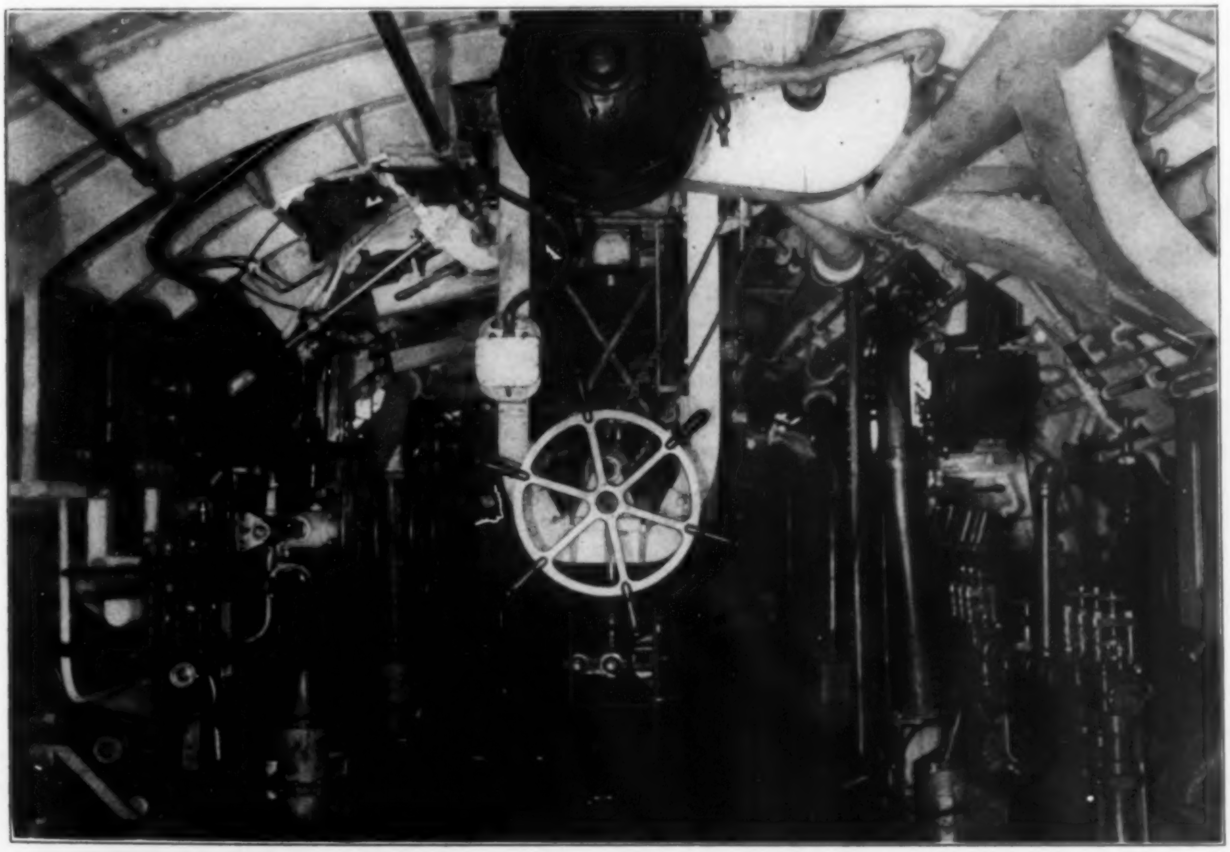


FIG. 12 FROM AMIDSHIPS LOOKING FORWARD

Fig. 12 gives a good idea of the mass of equipment of a submarine, every part of the space being utilized. The picture is taken from amidships looking forward. In the center of the picture is shown the hand steering wheel. In general the steering is done by an electric motor, shown at the top of the picture. On the left is the air manifold,

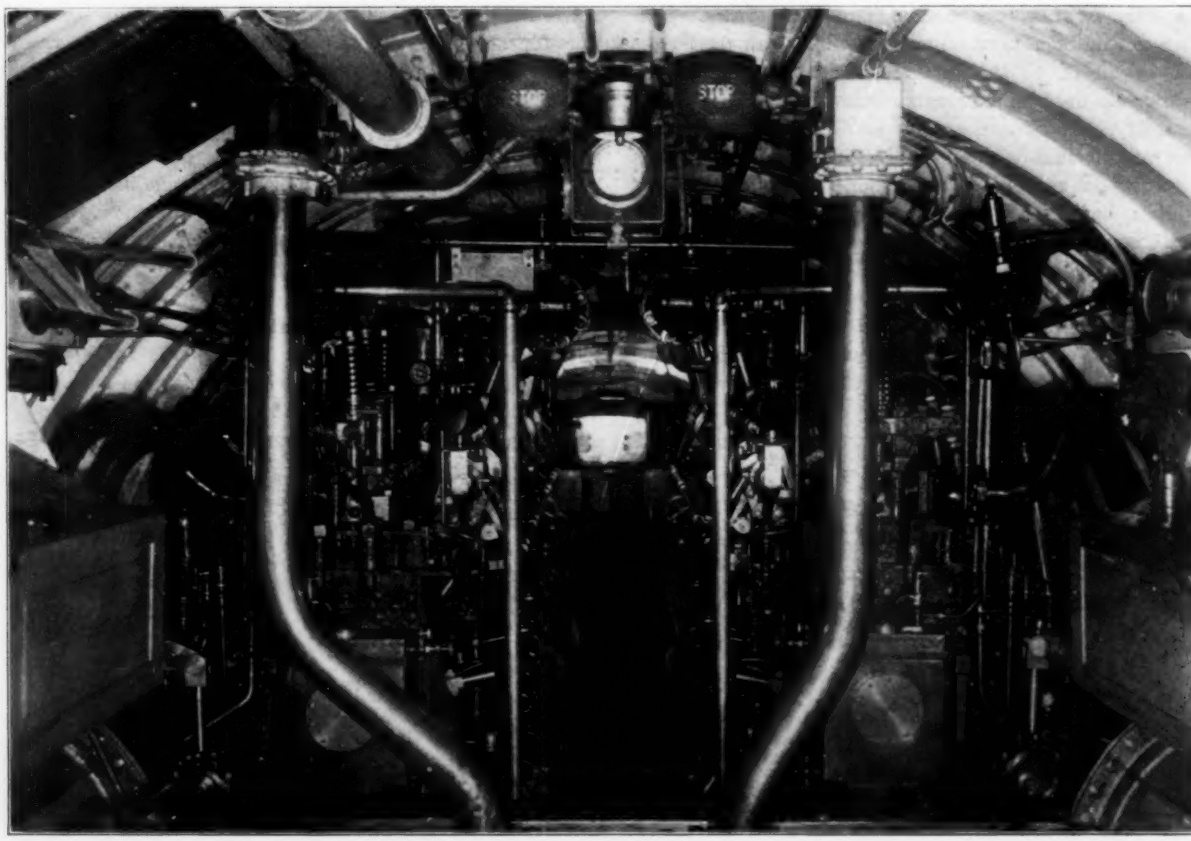


FIG. 13 FROM AMIDSHIPS LOOKING AFT

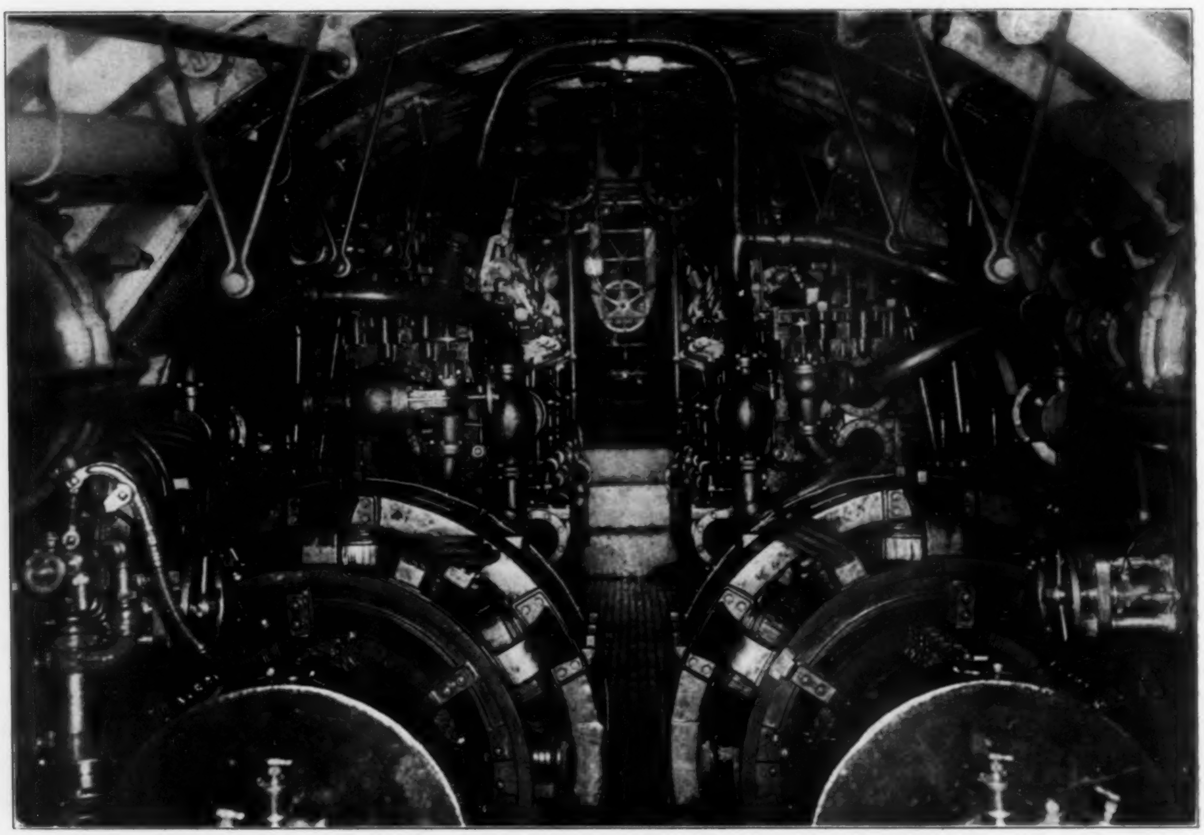


FIG. 14 FROM AFTER END LOOKING FORWARD

with valves for control of the high-pressure air. These valves connect the air to all the different tanks. By opening the valves to the main ballast tanks, the water may be blown out in a short period of time. On the right is shown the water manifold which connects the different tanks to the adjusting pump, also the levers of the large Kingston valves. Fig. 13 gives a view looking aft from amidships and showing the main engines, and Fig. 14 from the after end looking forward, showing main motors and engines.

One of the two engines for a submarine on the test stand is shown in Fig. 15. For many years the gasoline engine was the best at our disposal, but as gasoline is a bad thing to handle in the confined space of a submarine, we were glad indeed when the Diesel heavy-oil engine became available for this work. The development of these engines was quite advanced in Germany before any such marine engines were built in this country. In order that we might advance as rapidly as possible, all known engines of this type were examined by our engineers, and the conclusion reached that the engine built in Nuremburg was the best then developed. Steps were immediately taken to acquire the rights for this country, and we were thus able to get for our submarines the best engine then developed. Many of these engines were built and are now in operation in our submarines. In the building and operating of these engines we found there were many things we did not like, the principal point being that they were very complicated. In consequence a new engine was designed—illustrated in Fig. 16. This is the type of engine used in many submarines recently built and has stood hard service with wonderfully good results. The change from gasoline to heavy oil has brought out one very interesting characteristic, that is, that with a given quantity of heavy oil, twice the number of horsepower-hours may be obtained as from a like quantity of gasoline. Thus with a boat having a given fuel tank capacity, double the radius of action is obtained when the change from gasoline to heavy oil is made. Another point is that heavy oil costs about one-fifth as much per gallon as gasoline; thus, for a given number of horsepower-hours, the fuel of the Diesel engine costs but one-tenth that for the gasoline engine.

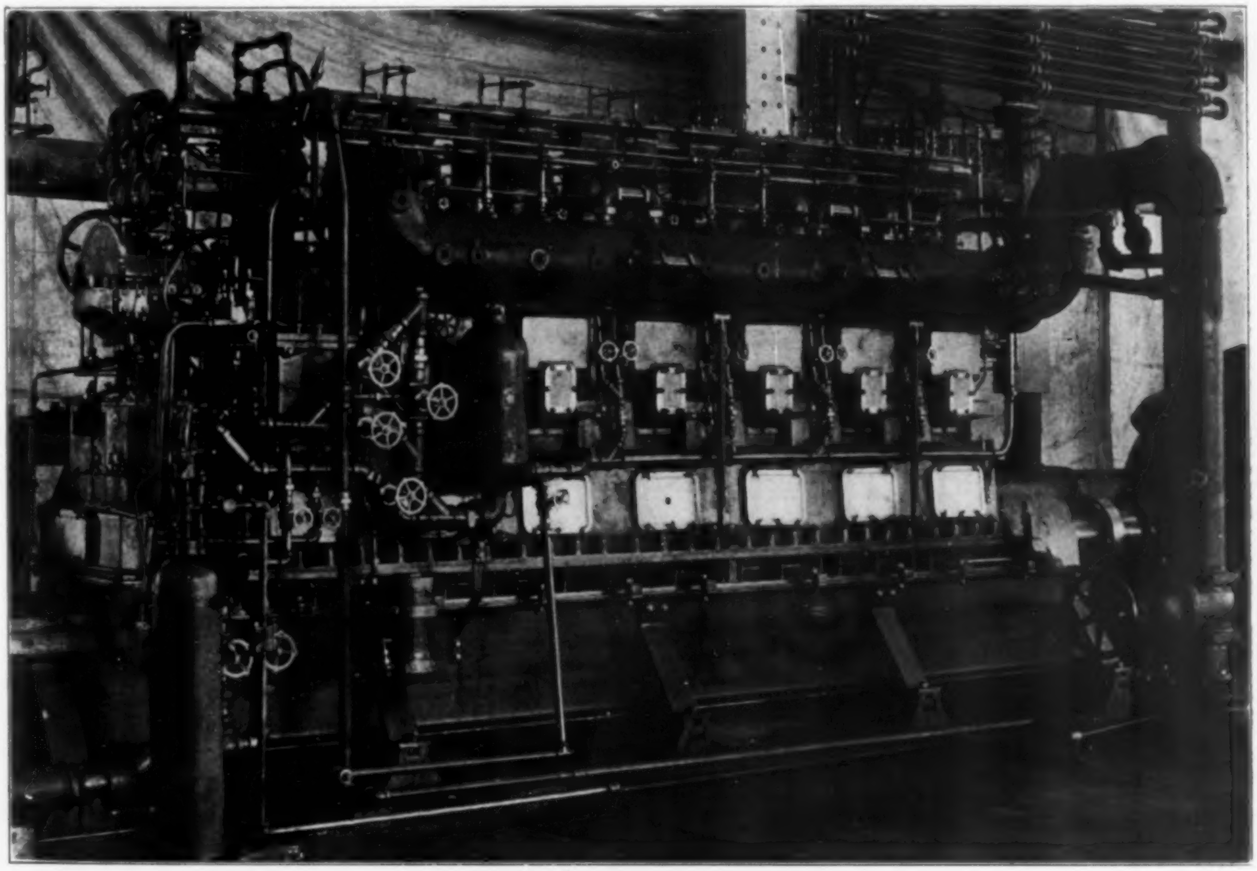


FIG. 15 450-HP. TWO-CYCLE DIESEL ENGINE

OPERATION OF SUBMARINES

The diving and behavior of the boat submerged is exceedingly interesting, and is shown in Figs. 17 to 23. In Fig. 17 we have the submarine stripped of all deck fittings and ready for submerged running. It takes but a few minutes to take down life lines, etc., close hatches and fill the ballast tanks. Fig. 18 shows the boat thus trimmed down and ready for submerged running. The buoyancy is about 800 lb. and when thus trimmed the boat may be steered down or up with the diving rudders, exactly as the usual steering rudder guides a surface boat. If now the boat is started ahead with diving rudders kept at zero, the boat will rise as shown in Fig. 19. That is, the natural tendency of the boat is always to rise. If now the boat is given a diving rudder, the stern will rise, the bow will go down as shown in Fig. 20 and the boat will slide under. When this photograph was taken the boat was making a quick dive, and the angle of the boat is about five degrees. In general but three-degree angles are

used in diving or rising, and for uniform running the boat angle will probably not change one degree. In Fig. 21 we see the boat well under, and in Fig. 22 she is running at a uniform depth. The actual distance of the boat from the camera when this picture was taken was but 94 yd., a very short distance over water. The control of depth even at high speed submerged is wonderfully accurate, runs being frequently made when for ten minutes at a stretch the depth will not change one foot.

If a submarine is resting on the surface and water is admitted to her tanks, she will gradually settle in the water. If care is exercised as the balancing point is reached the adjustment may be made so accurate that another gallon of water admitted to her tanks would cause the boat to sink. This is illustrated in Fig. 23, showing a boat weighing in the neighborhood of 400 tons thus evenly balanced. For the purpose of control of water in the tanks a small rotary pump is used, operated by a reversible electric motor. Thus water may be pumped either into or out of a tank. If when a boat is thus carefully balanced a little water is pumped into her tank, she will start to sink. Suppose after she has settled say to a depth of 40 ft. we pump out a little water. This will check her downward movement, and then she will start to rise. By watching the depth gage, and by careful control of the water by means of the pump, we may hold the boat suspended within a difference of depth of two feet. In general, after this test that of the automatic blow valve is made. This valve connects the high-pressure-air line with the main ballast tanks, and the control of the valve is by diaphragm in connection with the outside sea water. Thus if the pressure reaches too high a figure, the high-pressure air is automatically turned into the main ballast tanks. These tanks, it will be remembered, are entirely filled with water, whenever any is there, and therefore at such times the main Kingston valves are left open. The turning of the high-pressure air into these tanks is all the operation required to empty the tanks. In the test the automatic blow valve is set to some depth, say 50 ft., and the boat allowed to slowly sink. When this depth is reached the pressure outside operates the valve and some 75 tons of water are quickly blown out of the tanks. The boat immediately starts to rise, and in less than one minute will reach the surface, nearly jumping out of the water from the rapid rise. The automatic blow valve may be set for any depth that may be desired.

The subject of rescue of men from a sunken submarine seems to fascinate our inventors, as hardly a week passes but that some one comes forward with the same old method, that of a buoy of such a size that a man may get into it and then rise to the surface. It is not a question of getting a man to the surface—that is easily done, but of keeping him alive when he gets there. In this connection the statement should be made that there is only one cause that will prevent a submarine from coming to the surface, and that is a rupture of her hull. If now the hull is ruptured, the pressure of the outside sea is brought upon the men. In our respiration air is taken into the lungs, the oxygen taken up by the blood is used in the purifying of the blood, and a certain amount of nitrogen is retained in solution. This amount of nitrogen in solution in the blood is small at ordinary pressures, and in any case does no harm, for its quantity is a constant. If now a man is placed under heavy pressure, as would be the case if the hull of a submarine were ruptured say in 200 ft. of water, this pressure of about 100 lb. per sq. in. would cause the blood to absorb many times its normal quantity of nitrogen. This absorption takes place very rapidly, it requiring but a few minutes for the blood to become saturated to the point called for by the new pressure. If now a man so placed should enter a can buoy and rise to the outside air, the pressure would be quickly relieved and the excess nitrogen of the blood would be given off all through the system, given off in small bubbles which

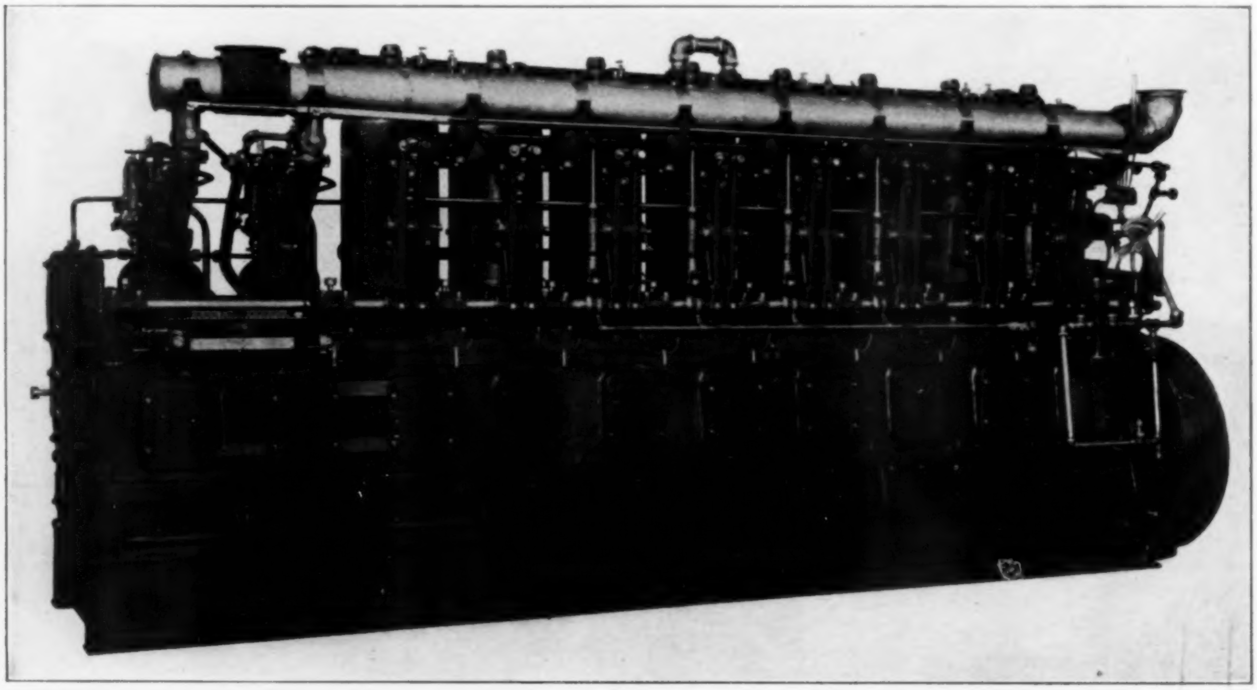


FIG. 16 240-HP. FOUR-CYCLE DIESEL ENGINE

would instantly stop all blood circulation and cause death. This action of the nitrogen is a familiar one to divers and all who are called upon to work under heavy air pressure. Thus it is not a question of the quick application of pressure, but the quick removal of that pressure. As an illustration, a few years ago a government diver went down some 280 ft. off New London. He took two minutes in going down, spent five minutes on the bottom, and then started for the

Fig. 17

Fig. 18

Fig. 19

Fig. 20

Fig. 21

Fig. 22

Fig. 23

Fig. 17 Stripped for Diving Operations

Fig. 18 Trimmed for Diving

Fig. 19 Starting Ahead with Diving Rudder at Zero

Fig. 20 Starting to Dive

Fig. 21 Diving

Fig. 22 Running Submerged

Fig. 23 Stationary Submerged

surface. He came up a little way and then stopped, exercised his arms and legs, thus encouraging activity of the blood in order to work the nitrogen off through his lungs. Then he would come up a little further and repeat the operation. The total time thus taken to reach the surface was one hour and thirty-five minutes, and even then as soon as he was taken out of his diving suit he was put into a recompression chamber so that the pressure might be still more slowly relieved. It will thus be seen how impossible it would be in the excitement of a wreck to go through any such procedure as outlined above.

Recent activities of submarines abroad have demonstrated the abilities of the boats, but generally the conditions are quite different from those that would pertain here in case we should be at war with one of the great foreign powers. Then the office of our submarines would be the breaking up of a blockade of our ports, or the preventing of an armed force from making a landing on our shores. Many times in naval maneuvers submarines have successfully attacked battleships, and where sufficient numbers of submarines are employed they may easily prevent a blockade by such ships. An interesting report was given some time ago of the breaking up of an entire expedition of a German army in its attempt to land at the south end of the Gulf of Riga, the work having been done entirely by two small submarines. If the report is true it shows wonderfully effective work by the submarines.

Engineering technological researches may be of great value to a country or to industries; but they inherently lack self-support. Any laboratory engaged in researches, the successful results of which are to be published, can only expect to be supported either by national institutions, by gifts, or by benevolent endowment. For this reason, although industrial researches are numerous and widespread, engineering researches are mainly restricted to universities, technical colleges and government laboratories.—*Science*, March 9, 1917.

THE MECHANICAL DEVELOPMENT OF AVIATION

By NEIL MacCOULL,[1] Pittsburgh, Pa.

The earliest systematic experiments with power-driven aeroplanes were started in 1889 by Sir Hiram Maxim, and from the data obtained he constructed a steam-driven twin-propeller aeroplane in 1893. The span of the wings was 104 ft., which to this day is exceeded only by very few machines. The total wing area was over 6000 sq. ft., which is some twelve times as great as that of the average military aeroplane; but this was necessary because it was intended to fly at speeds of only 35 to 45 miles an hour. In the experiments with this machine, the running gear was provided with flanged wheels which ran on a straight level track of 9 ft. gage. Strong wooden guide rails of 3 x 9-in. Georgia pine were constructed along the track in such a way as to prevent the aeroplane from leaving it. This aeroplane not only lifted its own weight of 8000 lb. but also broke the stout plank guide rails which held it to the earth, and caused a wreck. But in spite of being able to support itself, it could not be called a successful aeroplane because its stability and airworthiness were never demonstrated in free flight. The power plant was the one part which was successful, and I doubt if there has ever been a steam plant of its size which weighed so little as 11 lb. per hp., including boiler, engines, condensers, pumps, and water supply. Each of the propellers, which were 17 ft. 10 in. in diameter, was direct-connected to a double-acting compound engine with cylinders of 5 and 8 in. bore and a stroke of 1 ft., high-pressure cut-off being at ¾ stroke and low-pressure at ⅝. These were constructed almost entirely of high-grade cast steel and weighed but 320 lb. each, complete. With a steam pressure of 320 lb. per sq. in. each developed 180 hp. at 375 r.p.m., a weight of only 1¾ lb. per hp. A safety valve discharged into the low-pressure cylinder, thus adding considerably to the power when there was an excess of steam. The boiler which supplied the steam for both these engines was constructed of a very large number of ⅜-in. copper tubes 1/50 in. thick, and had a heating surface of about 800 sq. ft., including the feedwater heater. Tubing such as this was quite a novelty in those days. A strong forced circulation of water was obtained by means of a spring-loaded valve in the boiler which held the feedwater at a pressure of 30 lb. per sq. in. in excess of the boiler pressure. This fall of 30 lb. in pressure acted upon the water in the tubes and forced it down through the large outside tubes. Although this boiler with the casing, dome, smokestack, and connections weighed less than 1000 lb., it supplied all the steam the engines could possibly use. The weight of the engines and boiler totaled 1640 lb. or about 4 1/3 lb. per hp. The condensers were made of very thin copper, the individual tubes being shaped somewhat like miniature aeroplane wings in section. By this means they were made to sustain more than their own weight when the aeroplane was traveling at its normal speed.

At almost the same time, Samuel Pierpont Langley, the real *father of aviation*, was learning the fundamentals of aerodynamics by means of models with rubber motors. After years of experimentation successful steam-driven models were constructed, and after nine years of strenuous work there was evolved a steam-driven model known as No. 5, which had a wing spread of 13 ft. and weighed 26 lb., complete. On May 6, 1896, this model was launched over the Potomac River with a steam pressure of 150 lb., and started directly ahead into the gentle breeze then blowing. After the lapse of one minute and twenty seconds, when at a height of 70 to 100 ft., the fuel was exhausted and the aeroplane gradually descended until it finally touched the water after a flight of over 3000 ft. This was the first time in history that a mechanical device had actually flown through the air under its own power. The engine of this model was a single-cylinder 1 5/16 by 2¾-in. double-acting type with piston valve, and drove the two propellers through bevel gears. It delivered about ¾ hp. and weighed barely 1 lb. The complete power plant, including engine, flash boiler, pumps, tanks, etc., weighed less than 8 lb., which is under 11 lb. per hp., an exceedingly creditable result.

Mr. Langley started his aeroplanes from a sort of catapult, in which the aeroplane was held to a carriage running on a track, and was released after traveling the length of the track under the impulse of coil springs. The man-carrying aeroplane, tried out in 1903, was launched from a similar device, and failed only on account of some accident which tripped the machine just as it was leaving the car and threw it into the water. This happened twice and caused so much ridicule in the press that Mr. Langley was unable to get any further financial aid. A few years after Mr. Langley's death, Glenn Curtiss repaired this aeroplane, and, by fitting it with pontoons so that it could rise from the water, was able to make a very pretty flight. It is interesting to recall that the Wright Brothers used in all their early experiments a launching device operated by falling weights, and a catapult similar to Langley's is now used for launching aeroplanes from battleships.

President McKinley became interested in the military possibilities of aircraft as a result of Langley's experiments, and in 1898 caused the Board of Ordnance and Fortification of the War Department to authorize the construction of a man-carrying aeroplane under Mr. Langley's direction. It was decided that the new machine should follow the general type of the models, because heart-rending difficulties experienced during the preceding eleven years had taught that even a slight departure from the type that had been successful might be very costly. The great difficulty was the power plant, which even today is the source of the greatest troubles with aeroplanes. Steam was seriously considered because of its success on the models, but the internal-combustion engine, just coming into prominence in automobiles, seemed to offer a more satisfactory solution. At that time flights of sufficient duration for the weight of fuel to become serious were not considered, otherwise little attention would have been given to steam, beause the most efficient plant yet constructed uses twice as much fuel as modern aeroplane engines, and when boilers and auxiliaries are included, are over twice as heavy as Langley's large internal-combustion engine made later. For this reason it is astonishing to hear rumors at present of responsible organizations contemplating the use of steam turbines for aeroplanes. The turbine itself can be made very light, but the weight saved over a reciprocating engine would be lost by the weight of the reduction gear required to drive the propeller at the proper speed.

[1] Westinghouse Machine Co.

Abstract of paper presented at a meeting of the Philadelphia Section of The American Society of Mechanical Engineers, November 28, 1916.

In December, 1898, a contract was signed with an engine builder in New York City to supply a 12-hp. engine weighing not more than 100 lb., delivery to be made in $6\frac{1}{2}$ *weeks*. The engine was completed before that time, but it was impossible to get it to deliver more than 4 hp. It was the first air-cooled revolving engine built, and the problems which developed were too much for the builder. A quarter-size model of this engine, when changed so as to have fixed cylinders with cooling ribs, performed excellently. In the meantime, European engine builders who were interviewed said that they did not care to undertake the work, and that they did not consider it possible to construct an engine of 12 hp. weighing less than 200 to 300 lb. If possible, they would already have done so, as they had had numerous inquiries for such engines. In spite of the discouragement, Charles Manly, assisting Mr. Langley, offered to undertake the construction of the required engine from the parts of the unsuccessful engines built in New York.

A five-cylinder, water-cooled radial engine (Fig. 1) was the outcome of his efforts. Each cylinder was drawn from a 3/16-in. steel plate by J. A. Stimmetz, and then machined inside and out, leaving a 1/16-in. shell. To this shell was brazed the valve chamber, which had been machined from a solid forging. The jackets, of sheet steel, only 0.020 in. thick, were brazed on by Mr. Manly himself, since no one else would undertake the work. In spite of the trouble involved, it was less difficult than to deposit copper jackets electrolytically, so undeveloped were these processes only fifteen years ago. To minimize the lubricating difficulties which might be experienced if the pistons were to bear directly against the steel cylinders, cast-iron liners 1/16 in. thick were shrunk in. Although engine builders had declared such construction impractical, if not impossible, no trouble was ever experienced with these liners, and they served their purpose admirably. The difficulties of attaching five connecting rods to one crankpin without sacrificing necessary bearing area were solved by the use of a "master rod"; one rod has a sleeve around the whole crankpin, as is usual with single cylinder engines, and the other four rods bear on the outside of this sleeve. In this way the small bearings between the four rods and the master rod receive none of the rubbing effect due to the rotation of the crankpin, except that of slipping a very short distance over the sleeve during each revolution, on account of the angularity of the rods. This construction was successful from the start and is now used in a slightly modified form in nearly all radial and revolving engines.

In order to get a reliable and equally hot spark in each cylinder, the scheme was originated of using one spark coil and vibrator for all cylinders, with a distributor to select the correct cylinder for each spark. All procurable spark plugs were very unreliable because of the frequency with which they became short-circuited with carbon; to correct this, a special plug was made. The pocket around the points which is now known to be so valuable, eliminated all this trouble. The intake valves were automatic, and the exhaust valves were operated from a central cam. This cam, which had two points 180 deg. apart, rotated at one-quarter engine speed in the opposite direction. The light weight of the whole valve mechanism is noteworthy. All parts were lubricated by oil cups. This engine was completed in December, 1901, and was given three 10-hr. runs while connected up to water dynamometers. At 950 r.p.m. 52.4 hp. was delivered, giving a weight of 2.37 lb. per hp., based on the stripped weight of the engine, which is 124 lb. The complete engine, including balance weights, ignition coil and batteries, carburetor, radiator, water and gasoline tanks, and all other accessories; and with radiator, water tank, and jackets filled with water, is only 3.65 lb. per hp. This is more than 20 per cent. lighter than present-day water-cooled engines.

Thus two Americans succeeded in producing the first man-carrying aeroplane which could support its own weight in stable flight; Samuel Langley produced the aeroplane, and Charles Manly produced the power plant. Those of us who blush with shame because our government possessed less than 50 military aeroplanes a few months ago while European countries were making daily use of tens of thousands, will do well to realize that this aeroplane was developed by the support of our own military authorities long before other governments did as much, and if it had not been for the ridicule of a hostile press and the sneers of a self-satisfied public, our government would have been the first to have possessed practical military aeroplanes. All this work of Langley's was terminated in 1903. Four years later Blériot constructed an aeroplane of the Langley type, and was able to make flights of a few hundred yards. The evolution of this machine resulted in the well-known Blériot type, now famous as the first to cross the English Channel.

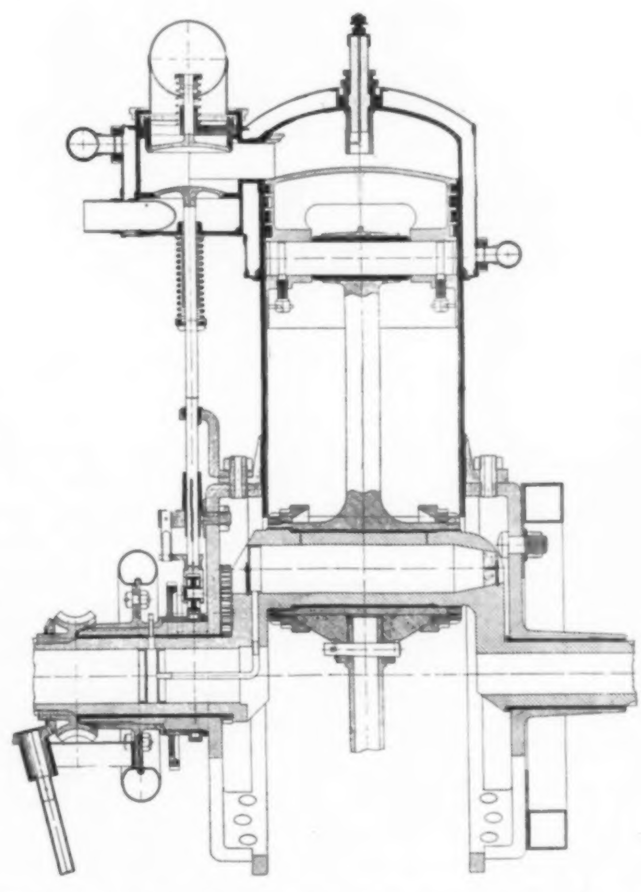


Fig. 1 Five-Cyl. Radial Engine (Fixed Cylinders) Built for Langley's Aeroplane in 1901. Cyls., 5 x $5\frac{1}{2}$ in.

Since then progress has been very rapid. Years elapsed from the time Langley solved the aerodynamic and mechanical details necessary for flight, before the Wright Brothers succeeded in flying for eleven minutes, and in 1914, only a few years later, the world's record for a non-stop flight was raised to 24 hr. and a distance of 1500 miles. This record still stands officially, for what has been done since the European War commenced is not accurately known by the public. Prèvost's speed record of 126 miles an hour made in

1913 still stands as official. An engineer just returned from Europe states that there are in France today 70,000 men wearing the uniform of the British Flying Corps, including pilots, mechanics, and other helpers. France and England together have about 14,000 licensed aviators, and Germany and Austria undoubtedly have as many. These 28,000 aviators do not include those of Russia and Italy. But even more astonishing is the statement made in the British House of Commons, that during the past two years Britain has spent $200,000,000 in aircraft. Another American engineer returning from Europe

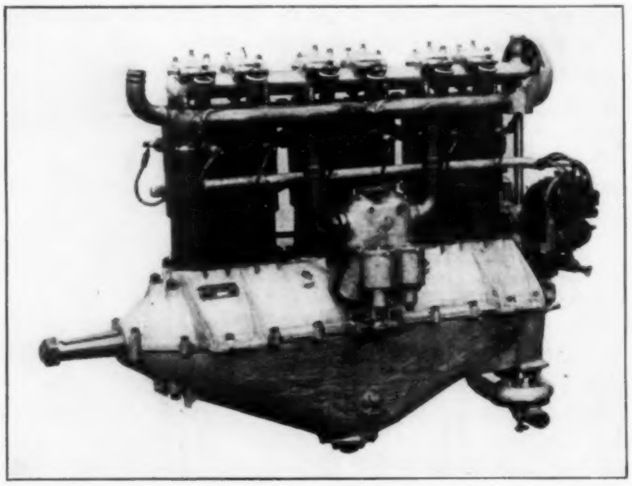


Fig. 2 The Famous Six-Cylinder Mercedes Engine Which Has Meant so Much to German Aviation

a year ago reported the sensations he experienced while flying several hundred miles in one of the Royal Flying Corps' giant triplanes which had a wing-spread of 135 ft., weighed just under 30,000 lb. and was propelled by over 1000 hp. in four units. The world will be dumfounded at the status of the aeroplane when the veil of the censor is drawn after the war.

One of the first engines to spring into prominence during the early development of aviation was the Gnome. It is an air-cooled revolving type, somewhat resembling Mr. Langley's early though unsuccessful engine, and is an example of the most beautiful workmanship of which French mechanics are capable; which is one reason for the fact that even now it holds the world's altitude and speed records. Its outstanding faults are that it requires a great deal of fuel and skilled attention. Up to about 100 hp. it is so much lighter than the conventional water-cooled engines that it will always have value where speed and quick climbing are essentials and long flights are not desired, such as in defending cities and fortifications from enemy aircraft. The La Rhone, another engine of similar type, considerably improved, is now manufactured by the Gnome Company. The intake and exhaust valves are located in the cylinder heads and are both operated by a single rocker. The rocker for each cylinder is operated by a pull-and-push rod, which in turn is given motion by a large cam within the crankcase. This cam, which operates all push-and-pull rods for the nine cylinders, has five points, because it rotates at 9/10 engine speed and in the same direction as the cylinders. The ingenious valve-driving mechanisms of many of these revolving engines make a very interesting study.

The great majority of modern aeroplane engines are an outgrowth of conventional automobile practice. One of the most famous of this type is the German Mercedes (Fig. 2); many of the latest engines follow it in general design. The most noticeable feature is the method of operating the overhead valves by an overhead camshaft. While this general type of valve drive is now the prevailing style, it was an innovation when developed on the Mercedes. It follows the fundamental principles of accepted automobile practice throughout. In fact this very engine was used in racing automobiles and has given their drivers many enviable records. No very great effort has been taken to make this engine especially light except in the cylinder construction. The cylinders, which are in pairs, are built up from steel by welding the individual parts together. The strong point of these engines has always been their reliability rather than absence of weight. Their designers, instead of looking for radical departures from standard types, in order to save weight, were willing to apply minute attention to the development of recognized engineering principles in every infinitesimal detail. One of the characteristics which is now found on practically all aeroplane engines is the double carburetor for six cylinders. Surprising claims of gains in engine power, some over 20 per cent, are made for the use of two carburetors instead of one. Another feature is the use of a double ignition system; two independent magnetos and two sets of independent spark plugs to each cylinder. The deep oil sump with the oil pump at its lowest point is another characteristic. Practically no aeroplane engine is lubricated by splash, high-pressure lubrication being used exclusively. One of the chief points in which designers have a chance to show their ingenuity is in the combination of the camshaft drive with the drive for the magnetos and pumps. In this engine a

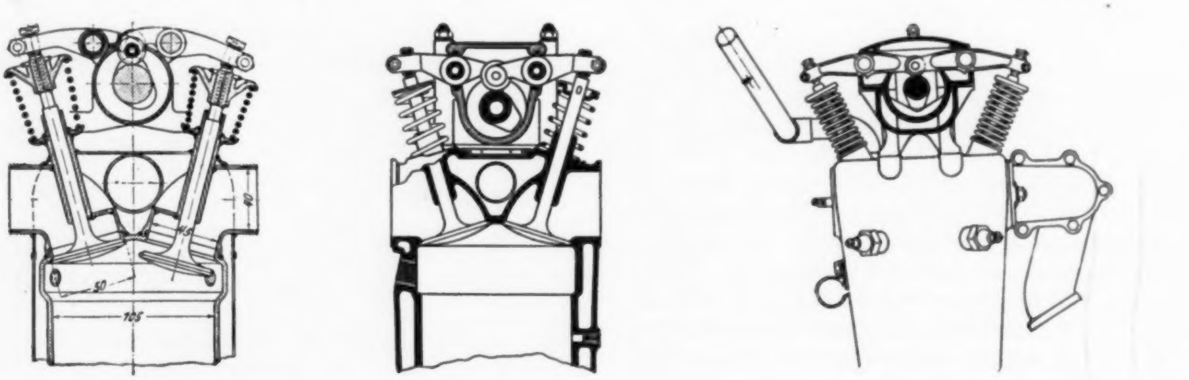


Fig. 3 Valve Mechanism of 3 Typical "Overhead Camshaft" Engines. Left, Mercedes; center, Hall Scott; right, Wisconsin

bevel gear on the crankshaft meshes with the bevel gears at the extremities of two vertical shafts, the upper driving the magnetos and camshaft through bevels, and the lower driving the centrifugal water pump at the lower extremity and in addition a horizontal shaft which in turn drives two oil pumps in the lowest part of the crankcase. It is a very neat arrangement.

From latest reports it seems that but few changes have been made in the designs of the Mercedes brought out since the European War commenced. The cylinders are increased in diameter from $4\frac{3}{4}$ to $5\frac{1}{2}$ in., so that the engine develops a maximum of 165 hp. instead of 100. They are now individual instead of in pairs but retain their welded-steel water jackets. The drive of the camshaft and auxiliaries has been modified so that the water pump is just below the camshaft bevels, the rotor being mounted on the vertical driveshaft which passes through it. This gives room for the oil pump where the water pump was formerly, and simplifies the drive of the former. These changes are design refinements which reduce the cost of manufacture and make the parts more accessible. The only departures in principle from former designs are the addition of cooling ribs on the bottom of the oil sump, and a set of decompression cams which are thrown into action by sliding the camshaft horizontally and make starting the engine by hand a fairly easy task, which is a matter of no small importance in an engine of this size.

One of the first American engines to follow the Mercedes is the Hall Scott. The cylinders, while individual as in the latest Mercedes, are cast with integral water jackets, giving a more rugged though heavier construction. The intake manifold and double-jet carburetor are water-and oil-jacketed, the oil jacketing not only warming the carburetor but cooling the oil. The valve mechanism of this engine is very nicely worked out. The camshaft housing is cast of aluminum and may be detached as a unit from the cylinders without disturbing the valve rockers. There are felt washers on each side of the rockers where they pass through the housing, and effective means are taken to lock the adjusting screws on the split end of the rockers. In all valve mechanisms of this type, the valves can be removed only by taking them out through the cylinders. The valve mechanism of this engine is shown in Fig. 3, in comparison with those of the Mercedes and Wisconsin.

Another six-cylinder engine of this general type is the Christofferson. The rocker arms are of different lengths as in the Mercedes, so that the valve has a 50 per cent greater lift than its cam. The whole valve mechanism is enclosed, which makes a very neat arrangement, and one that assures excellent lubrication of these parts, but it is doubtful if it is a wise policy to enclose the springs. It has been found very advantageous with many engines to allow the valve springs to project through the aeroplane hood so as to be sure that they will be well cooled. One of the most interesting features of this engine is a ring type of intake manifold, which allows each cylinder to draw its fuel mixture from two directions and would appear to give equal distribution to every cylinder without resorting to two carburetors. At the bottom of the crankcase is the oil radiator, which is beginning to be considered so valuable in preserving the proper lubrication of high-duty engines. The cylinders are made of steel and their jackets of aluminum, cast in pairs.

One of the well-known British engines is the Sunbeam. The 12-cylinder V-type rated at 220 hp. is the only L-head type of engine left on the aeroplane market now that the Sturtevant has been transformed. There are two carburetors for each row of cylinders, which are necessary to get the maximum power from the engine. It is of the high-speed type and runs normally at 2000 r.p.m., the propeller being driven at 1000 r.p.m. from the camshaft.

A new engine recently brought out by this company is a 12-cylinder V-type, rated at 320 hp. The L-head cylinders are abandoned, and the overhead valves are operated by 4 overhead camshafts. The valves are both mechanically opened and closed as in their racing automobiles, no springs being used.

For years the B. F. Sturtevant Co. has been a strong advocate of L-head cylinders, but has finally given in to the overhead type. The cylinders and heads are cast of aluminum and provided with steel liners and iron valve seats which are cast in the aluminum. The use of detachable cylinder heads is quite an innovation in the aeroplane world and shows a desire to make accessibility a stronger factor. As in the great majority of aeroplane and automobile racing engines, aluminum pistons are used, i. e., aluminum alloy, for pure aluminum is no more like its alloy than iron is like alloy steel, and in its unalloyed state would be absolutely worthless in this service. This engine is of the high-speed type with geared-down propeller, running normally at 2000 r.p.m. It is shown in Fig. 4.

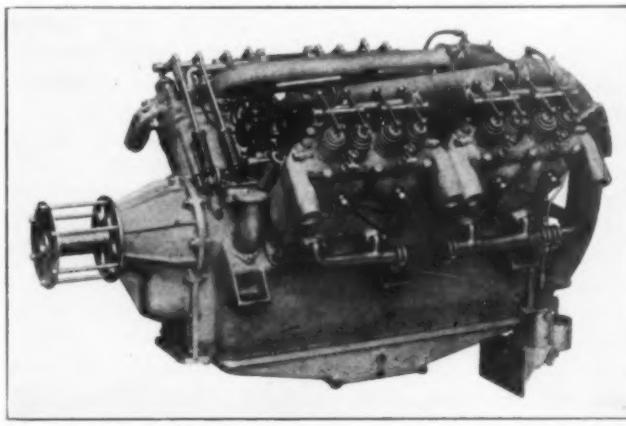


Fig. 4 The New Sturtevant 8-Cyl. "Aluminum" Engine with Overhead Valves and Geared Propeller Shaft. Normal Speed, 2000 r.p.m.: Cyls., 4 x $5\frac{1}{2}$ in.; Rated at 140 hp.

The manufacturers of the new water-cooled Renault have supported the twelve-cylinder V-type with forced-draft air cooling for years, and it is interesting to note that in their new 200-hp. engine, Fig. 5, they have adopted water cooling. They have also dropped the high-speed feature with geared-down propeller shaft, and the valve mechanism with camshaft in the crankcase, which have been characteristic features of Renault aeroplane engines. The valve mechanism is now strikingly like that of the Mercedes. Use is made of two double carburetors and four six-cylinder magnetos. The connecting rods are of the type in which one rod is pinned to a boss on the rod opposite it. This is used on no other engine except the new Wisconsin "twelve," though it must have given good results, because Renault has used it for so many years.

A 300-hp. engine just brought out by the Knox Motors Co. shows an innovation in aeroplane-engine valve mechanisms. Not only are the rockers unusually compact because of being bell cranks, but each arm which operates the valves is forked so as to open two valves from a single cam. There are two intake and two exhaust valves to each cylinder, which feature

very considerably reduces the stresses in these parts on account of lower inertia forces for a given valve area and results in much greater reliability and longer life. The cylinders are cast of aluminum, with cast-iron liners ⅛ in. thick. The pistons and the cylinder heads are of aluminum, the iron valve seats being cast integral. The oil pump at the bottom of the crankcase has a drive from bevel gears on the camshaft

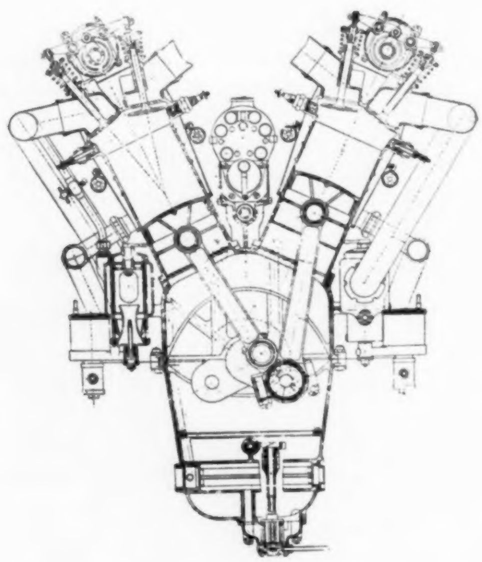


FIG. 5 12-CYLINDER WATER-COOLED RENAULT ENGINE. CYLINDERS, 4.9 x 5.9 IN. 200 HP.

layshafts which are driven by spiral gears. This engine is shown in Fig. 6.

The Wisconsin engine (Fig. 7) has been brought out recently by the same company that manufactured the engines for the famous Stutz racing automobiles, and embodies many of their best features. It is another instance of the intimate relations existing between aeronautical and racing automobile engines. The cylinders, pistons, and crankcase are of aluminum. The cylinders have hardened-steel liners 1/16 in. thick and the iron valve seats are cast integral with the aluminum. The magnetos are driven by spiral gears. Nothing is contained in the lower part of the crankcase except the usual oil filters. The twelve-cylinder engine is made up of two sets of the cylinders and valve mechanisms of the six-cylinder model, and is rated at 280 hp. Instead of driving the camshaft by layshafts and bevel gears, two trains of spur gears are used, and four six-cylinder magnetos are arranged across the front of the engine. Provision is made on most of these large engines for mechanical or electric starters and the electric generators for searchlights and wireless sets which are often carried.

So far the development of the aeroplane power plant has been dealt with, but engines do not cover all the mechanical parts of modern aeroplanes by any means. Mechanical starters alone make quite a study, and besides compressed-air distributors and air engines, include even small gasoline engines of about 4 hp. which weigh but 23 lb. with their own magnetos and carburetors. Then there is a special gun of large bore for aeroplane use, which fires out of both ends at the same time in order to eliminate the recoil. There are many special instruments to indicate the speed, angle of incidence, drift, altitude, and other factors necessary for the navigation of an aeroplane. Mechanical stabilizers also have developed into quite a study by themselves. In the Sperry system there are four small gyroscopes driven by three-phase current, which maintain a constant horizontal reference plane, and motion of the aeroplane about this plane closes electrical contacts which

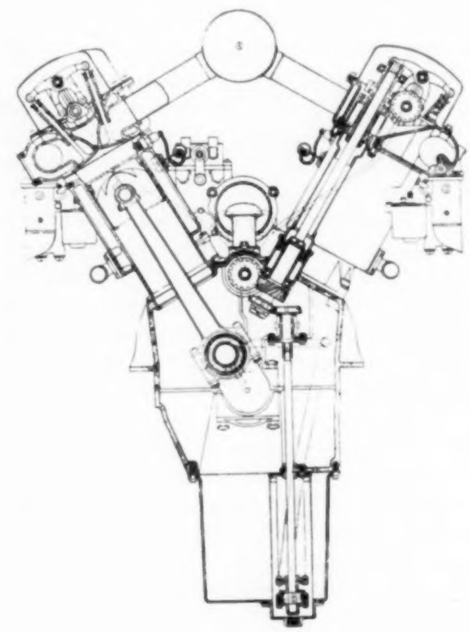


FIG. 6 12-CYLINDER AMERICAN KNOX ENGINE. CYLINDERS 4¾ x 7 IN. 300 HP.

operate clutches in the servo-motor. The windmill of the servo-motor, which is exposed to the relative motion of the air, is the source of power used in operating the controls. When the windmill reaches a predetermined speed, the blades fly outward, at the same time turning so as to reduce their

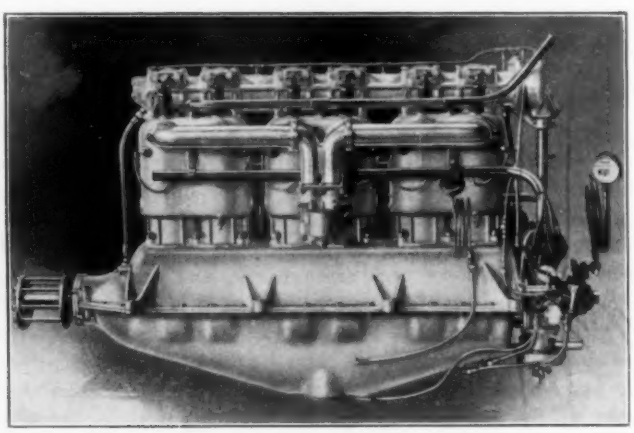


FIG. 7 CARBURETOR SIDE OF THE WISCONSIN ENGINE. CYLINDERS, 5 x 6½ IN.; RATING, 130 HP.

pitch, thus holding a constant speed. The magnetic clutches when energized connect the windmill to worm gearing, which drives the drums over which the control wires are wrapped. With this stabilizer it has been possible for the aviator to leave his controls and walk out on one of the wings while in full flight.

Descriptions of many mechanical parts of aeroplanes would not be expedient at this time because in many instances they would not be accurate even at the time they are read.

THE STEAM MOTOR CAR

By ABNER DOBLE,[1] DETROIT, MICH.

THE object of this paper is to recall the various objections to steam-driven motor vehicles which existed nine years ago when I first began my work on steam cars, and to tell of the steps to eliminate these objections.

The unsatisfactory points of the steam car were briefly, (1) low mileage on water, the average run on one supply of 35 gal. being 30 to 35 miles, although the Stanley is now securing about 200 miles; coincident with this necessity of frequently replenishing the water supply was (2) the formation of scale in the boiler, with a resultant drop in efficiency and added liability of burning the already extremely hot heating surface, which in turn necessitated the frequent cleaning of the boiler; (3) the toil and time involved in firing-up or lighting the main burner, which necessitated the use of matches and invariably required six or seven minutes or longer. The steam cars of eight or nine years ago also presented troubles of a less general nature; some had considerable difficulty with boiler leaks, some were too hot for comfort in summer, others carried their gasoline under high pressure and were altogether too easily ignited as a whole. Lastly, steam cars were very expensive to run, and their control and operation was a complex affair requiring intelligent and unfailing attention.

With the advent of the long-stroke, high-speed engine in Europe the internal-combustion motor came to be looked upon as the only practical power plant available, despite the admitted flexibility and smoothness of steam. I spent six years in building experimental steam-power plants and in experimenting. Late in 1913 we tried the combination of a fire-tube boiler with a honeycomb radiator to condense the exhaust steam. The results were truly startling. The car would run from 1000 to 1500 miles on one tank (24 gal.) of water. The effectiveness of the boiler was in no way lessened by the oil pumped into it.

The theory upon which we had worked was that in order to travel an adequate distance upon one supply of water, a honeycomb type of radiator must be employed to obtain the necessary cooling surface. The honeycomb radiator furnishes approximately six times the cooling surface of any other type of equal size. The reasons why this type had previously been deemed unavailable were the fact that the heavy molasses-like oil used in steam engines would clog up the extremely small radiator passages, and that the exhaust steam, particularly where a flash boiler was used, was liable to melt the soldered joints in the radiator. As far as I could find out, the use of a very heavy oil, especially where superheated steam was not employed, was a superstition. The presence of moisture in the steam goes a long way toward the proper lubrication of the cylinders and valves. In a steam-motor car little lubrication is required, as the piston speed is low at ordinary driving speeds, and the cylinder surface is cast iron, which is easy to lubricate.

In view of the foregoing it was determined to try ordinary gas-engine cylinder oil, and from the first it proved entirely satisfactory. To eliminate the possibility of melting solder in the radiator, we chose a fire-tube boiler. We realized that the presence of oil in the boiler would cause violent foaming, but believed that the high pressure used would eliminate trouble from this source. The normal steam pressure in the boiler was 600 lb., but as soon as the steam passed the throttle valve there was a large drop in pressure, sufficient to cause any water coming over from the boiler to pass into steam immediately.

Another reason why we did not use the customary heavy oil was because of the effect it would be certain to have upon the boiler. The action of the thin oil was all that could be desired. It immediately went into an intimate mixture with the water, due to the violent agitation and intimate contact. Agitation in the water tank was caused both by the motion of the car and by the fact that the return pipe from the base of the radiator entered the water tank very near the bottom. This also caused the water in the tank to act as a very effective supplementary condenser. The oil was accordingly regularly pumped into the boiler along with the water, and far from having a deleterious effect, really performed its most valuable functions in that part of the power plant. This oil is very thin at 420 deg. fahr., the approximate steam temperature at 600 lb. pressure, and the coating of oil, which forms over the entire inner surface of the boiler, is consequently so thin as to have a negligible effect upon the heat-transference conditions, and does not materially increase the liability of burning the heating surface.

As scale cannot adhere to a surface coated with oil, the interior of the boiler remains entirely free from incrustations of scale matter, and is likewise quite thoroughly protected from corrosion. The second function of the oil is to coat each particle of scale-forming material as it is thrown out of solution, thus preventing one particle from sticking to another in such a way as to form a body of sufficient size to clog some restricted passage. No large amount of scale-forming material is introduced into the system since but little make-up water is required, and all that remains in suspension until it reaches the water tank. The violent ebullition and constant flow of the medium toward the steam outlet causes the minute particles of scale to be carried along with the steam, so that the boiler and radiator are both kept free from deposits. The scale material finally reaches the water tank, where it either remains or continues to circulate through the system, without any apparent deleterious effect.

I have carefully examined the boiler and radiator of a car driven over forty thousand miles, and they were as clean or cleaner than when the car was built. I do not believe that there could be a more adequate proof of the entire effectiveness of the system. Lastly, the oil performs its normal function, being carried along with the steam in the form of minute globules, thus lubricating the throttle valve, cylinder walls and inlet valves.

DEVELOPMENT OF A STEAM GENERATOR

We next turned our attention to the development of a steam generator which would fill all our requirements. The fire-tube boiler, which had been successfully used in conjunction with our improved condensing system, possessed a number of the essential qualities we required; it held the temperature of the steam practically constant with no danger of sufficiently

[1] The General Engineering Co.

Presented at a meeting of the Cincinnati Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, February 15, 1917.

high exhaust temperatures to melt soldered joints or effect an undesirable change in the lubricating oil. It always kept a large reserve of water heated to the steam temperature, which gave it steaming stability and admitted of great acceleration. The heat-transference conditions caused it to be efficient, due to the extremely short distance, through which the gases of combustion radiated their heat to the tube walls.

On the other hand, it had its disadvantages: it was heavy and costly to manufacture, since it had to be wound with a mile of piano wire to minimize the potential danger present in a large-diameter shell. It was liable to leaks, which might be caused either by overheating with low water or by oil working through the expanded joints where the tubes were fastened into the heads.

The flash type of boiler was out of the question, but it had certain good points which I intended to include in my steam generator. The direction of the water flow opposite to the flow of the gases of combustion was a great advantage, in that it allowed the water to extract, as far as possible, the last remaining thermal units. The all-steel construction, with its consequent freedom from leaks due to low water, was another very desirable feature. The water-tube boiler seemed to have little in its favor except safety due to the small diameter of the tubes, and the possibility of so constructing it as to have a good supply of water heated to approximately steam temperature. We had, however, already eliminated the possibility of scale settling in the boiler, so it seemed possible that we could use it as a basis upon which to combine the desirable characteristics of the other two types.

After much experimental work we finally worked out our present steam generator, similar in theory to the flash boiler, yet in appearance more like the water-tube boiler and having a water level in the evaporating zone. It consists of a number of identical sections of cold-drawn seamless steel tubing. Each section consists of an upper and lower header and sixteen vertical tubes. The vertical tubes are swaged at either end to half their diameter and are welded to the headers by the autogenous acetylene process, making each section in effect one piece of steel and actually stronger at the joints than the tubing itself. The generator is designed for a working pressure of 600 lb., and the safety valve is set for 1000 lb. Each section is tested to withstand 5000 lb., and ruptures only occur when the pressure is made to exceed 8000 lb. cold-water pressure. When this does occur, the rupture is invariably remote from the welds.

One third of these sections forms the economizer, the remaining sections being used for the actual generation of steam. They are placed very close together and completely encased by a 3/4-in. wall of kieselguhr brick, which we have found excellent. This is held in place by a planished-iron jacket. Directly below the evaporating sections is the combustion chamber, and below the economizer is the exhaust for the gases of combustion. A bridge wall three fourths the height of the generator divides the two sets of sections. A manifold, through which water enters, connects the lower headers of the economizer sections. The water leaves by a similar manifold at the top and is led to a manifold connecting the lower headers of the evaporating sections. The steam leaves the upper headers and is conducted through a fourth manifold to the throttle valve.

Besides being absolutely free from any danger of explosion a boiler of this construction is cheap to manufacture, and any damaged section can either be easily and cheaply replaced, or isolated in a very few minutes by blanking it off until it can be replaced. The excellent heat-transference conditions due to the close and regular heating surfaces virtually duplicate those of a fire-tube boiler, while a large reserve of water close to steam temperature is always present. The progressive flow of the water counter to that of the gases, with no circulatory flow, and the all-steel construction show a distinct similarity to the flash type. Water is supplied to the boiler by a crank-driven pump, and the water level maintained about half way up the generator by an automatic regulator. If the water level falls below normal the regulator tube will fill with steam and its expansion closes a by-pass valve, thereby allowing water from the pump to enter the boiler. As soon as the level reaches normal, the regulator tube fills with water which has not been in circulation in the generator and is therefore comparatively cool. The regulator tube at once contracts, permitting the valve to open and all water to be by-passed back to the supply tank.

THE COMBUSTION SYSTEM

The most uncertain feature of the steam car, and one of its greatest disadvantages, was getting the burner properly ignited. Practically every steam car has used a bunsen burner of the vaporizing type. In order to insure sufficient mixture reaching the combustion space to ignite readily and continue burning, preheating was required to vaporize the fuel. Once the burner was going properly the vaporizer was heated by the fire, but when the car was not to be used for a time a supplementary burner was kept lighted to maintain the vaporizer heat and ignite the main burner when it was again necessary to generate steam.

On more modern steam cars acetylene gas has been used to heat the vaporizer. It considerably alleviated the difficulty, but meant an additional fuel tank to carry and replenish. After the vaporizer was hot the fuel valve was opened slightly, allowing the passage of only a very small amount of fuel until the burner itself had become thoroughly heated, and not until then could the fuel valve be left wide open without flooding the burner. When the fire was finally well started, steam was made quickly. With certain types of boiler sufficient pressure for starting could be generated in a minute and a half after the main burner was going. The chief problem of quick starting was therefore to eliminate the time required for lighting the main burner. The first real step we made in the right direction was to abandon entirely the former steam-car system and borrow a leaf from the book of gas-engine practice.

The idea was to use a spark plug for ignition, a carburetor for mixing the fuel and air, and an electrically driven blower to supply a forced draft. This worked fairly well as long as gasoline was used for starting, except for considerable precipitation of the fuel. We became more ambitious, however, and determined to make use of nothing but kerosene. The attainment of this more difficult goal required a large amount of experimental and laboratory work, but we finally determined that cold kerosene could invariably be ignited by an electric spark, if the following conditions were observed:

1 The kerosene had to be broken up mechanically into sufficiently small particles to insure a rise in temperature past the point of ignition during the time in which they absorbed heat from the spark

2 The spark had to occur close to the atomizing nozzle at a point where the resultant fog was sufficiently dense to insure one group of kerosene particles invariably igniting the rest

3 The velocity of the fuel particles had to be low enough to permit them to absorb sufficient heat from the spark to raise their temperature beyond the ignition point

4 It was essential that the mixture be much richer in the vicinity of the electric spark than that which would provide the most efficient combustion. In the latter connection we also found that in order to secure complete combustion of a large amount of fuel in a small space, it was necessary to utilize a combustion chamber made of a highly refractory material designed to attain a very high temperature.

To meet these conditions we developed the apparatus which we now use. The electric current is supplied primarily by a generator driven by the main driving gear. This charges a storage battery, which furnishes the ignition spark and drives the motor blower. As there is but comparatively little demand upon the ignition, we can afford to use a primary current of high amperage and accordingly secure an unusually hot spark. The kerosene is fed under low air pressure to a float chamber similar to that of a gasoline carburetor but of special design. A jet fed from the float chamber projects into a venturi tube perpendicular to the center line of the tube. The level, when the apparatus is not in operation, is somewhat below the mouth of the jet. A multivane blower driven by a small electric motor forces air through the venturi tube into the combustion chamber. The passage of the air creates a vacuum of several inches in the fuel jet, causing the kerosene to pass the spark plug as a fog of very finely atomized particles. The tube widens considerably before the point where the spark occurs, thereby appreciably diminishing the velocity of these particles.

As soon as ignition occurs, the heat of the fire causes a bi-metal switch to break the spark circuit, and the fresh fuel continues to be ignited by that which is already burning. When the steam pressure reaches 600 lb. it breaks the motor-blower circuit and fuel ceases to enter the combustion chamber. As soon as the pressure decreases to 550 lb. the circuit is remade and the spark once more ignites the fuel. This arrangement maintains the pressure in the generator virtually at normal without any attention on the part of the driver. Another motor-blower circuit breaker is used as a safeguard against the possibility of low water in the generator due to lack of water in the supply tank. In this case the breaking of the circuit depends upon the expansion and consequent elongation of the lower header of one of the generator sections when it becomes overheated.

This generator was rated at 75 hp., was 32 in. long, 22 in. wide and 28 in. high. The heating surface was slightly in excess of 150 sq. ft. When ignition took place the water in the generator was at 66 deg. fahr., but reached 212 deg. in forty seconds; in eighty seconds the pressure was 100 lb.; it reached normal, or 600 lb., two minutes and fifty seconds after the switch was turned, the increase from 500 to 600 lb. requiring just ten seconds. In order to maintain a full head of steam, 600 lb., it is only necessary for the combustion system to operate seven seconds in every twenty minutes. This applies when the car is standing where the surrounding temperature is about 60 deg. fahr.

THE ENGINE

In designing the engine my chief concern was to provide ample dimensions of the working parts in order to insure continued operation under maximum conditions of load. Although the compound engine may provide for high expansion, it is not desirable for use in motor cars, as the ratio of the cylinder volumes has to be carefully determined in relation to the probable loads, speeds and steam-chest pressures. In the steam car these conditions vary so widely that it was necessary to use the single-expansion engine.

I employed the uniflow principle, because I wished to secure high expansion with a simple, noiseless valve gear and one valve per cylinder. The inlet valves are placed on top of the cylinders. They are of the slide type, and are so constructed as to lift off their seats if the compression at any time exceeds the steam-chest pressure. Another reason for the uniflow was the fact that it makes unnecessary the use of superheated steam, as the thermal conditions in the uniflow cylinder approach the ideal. All troubles caused by superheated steam are therefore absent, and but little cylinder lubrication is necessary. The exhaust is through ports uncovered by the piston at the end of its stroke. With this arrangement it is possible to secure cut-off as early as 10 per cent of the stroke. The inlet valves are actuated by a simplified form of the Joy valve gear, thus dispensing with eccentrics and making possible a one-piece crankshaft. It differs from the Joy in that it dispenses with the connecting and anchor links, and has a straight instead of a curved rocker guide.

This gear operates the $\frac{1}{4}$ cut-off, which is used for all ordinary running, with perfect accuracy, and the slight variation at $\frac{5}{8}$ cut-off, which is used for starting or heavy pulling, and at $\frac{1}{8}$, used for high speed or economy, is not noticeable in the running of the car. To provide against water in the cylinders or a leaky throttle valve, a small piston valve is placed on the lower side of the cylinders. This valve is normally held open by a spring. It is connected to the four clearance spaces of the cylinders, and any water or steam not under sufficient pressure to actuate this valve passes through it to the atmosphere. As soon, however, as any steam under an appreciable pressure reaches it, the pressure will force down the piston and close the valve. The engine is geared to the rear axle in the ratio 47:49, or virtually one to one; yet can produce sufficient torque to slip the driving wheels on dry pavement. On account of the low engine speed an elaborate system of lubrication for the engine mechanism is entirely unnecessary.

I will sum up the chief advantages of such a steam-power plant for motor-vehicle service.

1 Torque range of 100 per cent with a maximum torque available at zero speed; change-gear mechanisms and clutch therefore unnecessary

2 Mean effective pressure (and equivalent drawbar pull) always under control of the operator; variable by throttle and cut-off from zero to maximum, a maximum limited only by the tractive capacity of the rear wheels

3 Utmost mechanical simplicity with not over twenty-four moving parts in the entire car and only eleven in the engine

4 Smooth and quiet operation, due to low engine speed and to location of the engine

5 Low manufacturing cost, owing to simplicity of construction and lack of "fussy" work in production

6 Entire absence of lubrication troubles; no contamination of crankcase oil by kerosene, gasoline, water, road dust, or carbon

7 Low fuel cost per mile.

In connection with this last point, some very brief statistics may prove of interest. As a basis of comparison, we selected three well-known gas cars, the first being a six-cylinder car

weighing slightly over 2300 lb and developing a maximum of about 40 hp.; the second weighs 2700 lb., has six cylinders, and can develop 45 hp.; the third, a twelve, weighs 4400 lb., and develops 80 hp. Our steam car has a generator rated at 75 hp., and weighs 3500 lb.

The four cars may be known as *A*, *B*, *C*, and *D*, and the results at 40 m.p.h. on a level road were as follows: *A* delivered 15.1 hp. at the engine, 12.3 hp. at the rear tires, and traveled 21.3 miles per gallon of gasoline. *B* showed 14.3 hp. at the engine, 10.6 hp. at the wheels, and ran 15.4 miles per gallon of gasoline. *C* developed 36.1 hp. at the motor, 29 hp. at the wheels, and obtained 9.5 miles to the gallon. *D*, the steam car, at 40 m.p.h. develops 13 hp. at the engine, 10 hp. at the rear tires, and secures 11.4 miles per gallon of kerosene.

With gasoline at twenty cents and kerosene only eight cents per gallon in Detroit, there appears to be a considerable balance in favor of the steam car, but it is at the more normal driving speed of twenty miles per hour that the best economy showing is made.

A, a light car well known for its fuel economy, at 20 miles per hour ran 31.5 miles on one gallon of gasoline; *B*, 22.7 miles; *C*, 14.8 miles; and *D*, 17.3 miles on a gallon of kerosene.

REDUCING FRICTION BY AUTOMATIC LUBRICATION

By J. WM. PETERSON, MILWAUKEE, WIS.

Member of the Society

It is my vocation to make things run smoothly, and as has been so aptly said: "Blessed are they that remove friction—that make the courses of life smooth and the intercourse of men gentle." It is not work that kills off so many of our prominent business men before they have reached their allotted three score and ten, it is worry. Revolution does not destroy machinery, it is worn out by friction, which is the worry of work.

Friction is the resistance produced by two bodies coming in contact in a sliding or rolling motion. The product of this resistance or friction is a rise in temperature. You can warm your hands by briskly rubbing them together. Now, put some oil between your hands, and you can rub all day without producing enough heat to feel it. There is just this much difference between properly and poorly lubricated bearings.

It has always seemed to me that friction and its natural antidote, lubrication, have not received as much study from engineers as their importance would warrant. For instance, in a recent book by Archbutt and Deeley,[1] authorities on lubrication, one finds the remarkable statement that more than one half of the 10,000,000 hp. developed in Great Britain is expended in overcoming friction, and that a considerable portion of this wasted power is due to faulty lubrication; and again, in Professor Thurston's[2] classic treatise on Friction and Lost Work we find the statement: "It may probably be fairly estimated that one half the power expended in the average case, whether in mill or workshop, is wasted in lost work, being consumed in overcoming the friction of lubricated surfaces."

While the two statements quoted are general, they are based upon the experience of two well-known authorities. With these figures in mind, when we purchase new machinery let us not be so foolish as to quibble for that fraction of a per cent in efficiency guaranteed for our new engines or machines, and pass lightly over the question of lubrication or make no mention of it at all in our specifications. Let us not lose sight of the fact that the efficiency of an expensive machine may, after a few months of service, become lower than that of a less expensive machine, simply through lack of an efficient system of lubrication. A prominent dealer in second-hand machinery has remarked that in the purchase of any second-hand apparatus he always looks first at the bearings, for their condition largely determines the value of the machine in his eyes. In other words, if the machine has a good system of lubrication, the second-hand value is considerably higher.

Probably the reason friction losses are not so forcibly impressed upon us is because of their insidious nature. We can see leaks in the steam piping and repair them, our CO_2 recorder instantly shows improper methods of firing boilers, a thermometer tells us when our flue gases are too hot or our feedwater is too cold, and our voltmeters indicate the voltage of our electric generators, so that we can correct defects; but the losses caused by friction are not so obvious nor so easily measured. It is only when it becomes excessive—when the bearing becomes decidedly overheated or the babbitt starts to run out—that we become impressed as to the enormous power-consuming properties of friction.

The antidote for friction is scientific lubrication, or the application of a lubricant of the right kind at the right place and in the right quantities. It is the proper valuation of the last three items that gives us the most trouble and usually requires the services of a competent lubrication engineer. In order to give these points brief consideration, I will divide lubrication into two parts, first, interior or cylinder lubrication, which is delivering oil into cylinders and valves against the pressure of the steam, air or gas; and second, bearing lubrication.

CYLINDER LUBRICATION

This problem places us between the two horns of a dilemma. We know that the more oil we use, the smaller will be the amount of power consumed by friction, but we know also that most of the oil which is mixed with the steam going into the cylinder passes out with the exhaust and is forever lost. Up to the present time no good commercial system has been devised for separating oil from exhaust steam or the condensate and rendering it again suitable as a lubricant for cylinders. Of course a certain amount of oil can be removed by line separators, etc., but this is usually mixed with so much water and is so thoroughly emulsified that it is not suitable for further cylinder lubrication. The object in cylinder lubrication is to secure the highest degree of lubrication with the smallest amount of oil.

[1] Lubrication and Lubricants, 3d ed., p. 50.

[2] 7th ed., p. 12.

Presented at a meeting of the Milwaukee Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, December 20, 1916.

Another reason for keeping the amount of oil as low as possible is that as it is impractical to remove it from the condensate, and a large proportion of the oil finds its way into the boilers and makes trouble, for oil is quite an efficient heat insulator. Wm. Parker, Engineer-in-Chief of Lloyd's Registry, found not long ago that by painting an open steel dish with three or four coats of greasy deposit taken from the bottom of a boiler and mixed with cylinder oil, it was possible to burn the dish before the water in it boiled. This might be called a side line of lubrication, but lubrication engineers have to take it into consideration.

Within the memory of the youngest engineer cylinder lubrication has gone through many changes. First, suet or tallow was injected through a small hole in the cylinder every time the engineer happened to think of it. Next, grease cups were used, grease being supposed to be reduced to a liquid and flow into the steam chest, lubricating the valves and cylinders; but as the grease was usually cooked out of the cups, it went everywhere except where needed. Next came the hydrostatic lubricator, in which two or three feet of water pressure is used to force the oil into the steam. The last and most important step was the general adoption of the mechanically driven force-feed lubricator, in which the oil is positively, and at regular intervals, forced into the cylinders by means of pumps.

Most plants have adopted the system of force-feed lubrication for the main power units, but there are many depending upon more or less antiquated methods for supplying cylinder oil to their auxiliaries, such as pumps. Many engineers do not consider the auxiliaries of enough importance to warrant the refinement of automatic lubrication, but as auxiliaries are usually located in the basement, boiler room, or other out-of-the-way places, where they do not receive as much attention as the main units, automatic lubrication of such machines is of at least as much importance as that of the main units. The amount of power consumed by the auxiliaries, compared with the main units, clearly shows that lubrication of the former must be carefully considered.

For illustration, take one of the largest railway houses in the country. The areas of the rubbing surfaces of the main units in this plant amount in all to about 1,507 sq. ft., while those of the steam and air ends of the auxiliaries, air compressors, vacuum pumps, etc., total about 530 sq. ft.; thus there is one-third as much rubbing surface in the auxiliaries as there is in the main units, and as some of the auxiliaries are automatically started and stopped without supervision, it is evident that they should not only be supplied with a good system of lubrication but also with one which will start and stop automatically with the machines to which it is attached.

The power consumption of auxiliaries is more striking in smaller plants than in large ones. For instance, in the Marbridge Building 34th Street and Broadway, only 50 per cent of the power produced is used by the main generating units, the remainder being consumed in elevator pumps, blower engines, vacuum boiler feed, house pumps, air compressors, etc. In the power plant of a modern apartment house in New York City, two-thirds of the total power is consumed in the main units, the other third being used for refrigerating machines, boiler feed and house pumps, vacuum cleaning systems, sewerage pumps, etc. These are only a few examples, but there are many plants where, even though the main units are properly lubricated, the cost of lubrication could be greatly reduced and the plant efficiency improved if the auxiliaries were equipped with an efficient system of lubrication.

Properly designed force-feed lubricators deliver a predetermined amount of oil and the delivery is not affected by changes in temperature or the viscosity of the oil. They are much cleaner and neater to handle than hydrostatic lubricators and can be filled while in operation or connected up to a central system of supply, and will effect a saving in oil of at least 50 per cent.

BEARING LUBRICATION

The problem of adequately lubricating bearings is entirely different. In the old days the engine had a few holes and the engineer had to treat it to a dose of oil on frequent visits; in some instances bearings were provided with grease cups, and instead of a dose of oil he would, on his regular rounds, give these cups an extra twist. Nothing similar to this is now seen in the modern power plant. Economical lubrication requires the installation of modern scientific apparatus which will automatically apply the oil in a manner that will do the most good. Poor lubrication increases wear and tear, reduces the life of machinery, and wastes a large amount of power by friction, resulting in increased fuel consumption.

The only economical method of lubricating bearings consists in supplying as much oil as the bearings will take and of collecting, filtering, and using it over and over again. In passing through the bearings the oil takes up small pieces of metal removed from the bearings by friction, dust, etc., also water from condensed steam, which has leaked past the stuffing boxes. If solid matter and water are properly removed from the oil, it is in a condition to be used over again; therefore the crux of a good automatic system of lubrication is the filter, wherein the oil is restored to its original pure and clean state. An engine or machine equipped with an efficient system of continuous lubrication feeding a stream of oil to all bearing surfaces will run much cooler, wear longer and render the necessity of keying up less frequent than is the case where lubrication is provided by oil cups feeding drop by drop.

In the power plant of a shoe factory the engine-room log shows that before the adoption of continuous stream lubrication it was necessary to key up the pins about once every two weeks, whereas since the oiling system was installed, keying up is only necessary every six to eight weeks. One of the engines in this plant, a 200-hp. Corliss engine, is equipped with an individual oiling and filtering system, and the make-up oil only amounts to two gallons per month. A further illustration of what can be accomplished with a properly designed automatic system of bearing lubrication is furnished by one of the largest public-service plants in the country, where 30,000,000 kw. are generated each month. The total amount of oil consumed for all the main generating units and their auxiliaries amounts to only 300 gal. per month; and in another plant the actual cost of cylinder and bearing lubrication amounts to only two cents per 1000 kw-hr.

PLANT EFFICIENCY

The work done by a steam engine is necessarily divided into three parts; that done against the outside load, which alone is the useful work; that done against the back pressure in the cylinders; and that done against other resistances, the most important of which is friction. Work is also done at the beginning of each stroke in overcoming the inertia of the moving parts, but in a properly designed engine most of this should be restored to the engine before the end of each

stroke. In the modern type of engines the mechanical efficiency is very high. In tests of ten new engines of different makes—four simple, four compound, one triple expansion and one quadruple expansion—the mechanical efficiency ran from 93 per cent to 97 per cent.

In engines not so modern in design and which have been running for some time, the mechanical efficiency may be surprisingly low. In one of fifteen engines tested of this class, which have been operating from ten to twenty years, the mechanical efficiency averaged about 70 per cent. In one case it ran as low as 60 per cent. If the mechanical efficiency is 70 per cent, the recoverable loss would be at least 20 per cent. Take a plant of, say, 1000 hp. The cost of producing a horsepower per year is about $30. A loss of 20 per cent would be 200 hp. at $30 per year, or $6,000.

The values for the mechanical efficiencies of steam engines are about as follows: 95 to 98 per cent, rare and unusually high; 90 to 95 per cent, usual good practice; below 80 per-cent, decidedly low. Experiments on distribution of friction show that the greatest loss, amounting to one-third or one-half of the total friction, occurs in the main bearings; the next important loss is that of the piston and piston rod, amounting to about 21 per cent of the total friction. Of this amount 6½ per cent is chargeable to the friction of the piston and rings against the cylinder walls, and about 14 per cent to the stuffing box of the piston rod, leaving 1.7 per cent chargeable to unaccountable losses. The losses due to friction of the working parts of an engine include considerably more than the mere loss of power, namely, the depreciation resulting from wear of bearings, guides, and other rubbing surfaces, and the expense arising from accidents traceable to excessive friction.

DESIGNING LUBRICATION SYSTEMS

There has always been a great deal of guesswork, mystery, and secrecy on the part of manufacturers in regard to the general design and installation of automatic bearing-lubrication systems for power-plant machinery. The lack of general information on this subject has resulted in the installation of many unreliable oiling systems not really suited to conditions existing. The requirements of an efficient lubricating system are:

1 A stream of clean oil supplied continuously at just the points where needed,
2 A filter which will thoroughly remove all dirt, small particles of metal, and entrained water, and properly cool the oil,
3 The system should be automatic in its operation and absolutely reliable.

One sometimes hears the statement made that oil becomes worn out through use. This is not the case, as has been amply proved by extensive tests made by several eminent authorities. There may be some slight increase in its specific gravity after it has been used continually, owing to the fact that by increase of temperature some of the more volatile oils are driven off and small amounts of cylinder oil used for lubricating the piston rods, etc., become mixed with the bearing oil; however, the heavier oil is still as good as ever, if properly treated. In some cases the mixture of cylinder oil with the bearing oil, which gets into the system from the piston-rod lubrication, causes serious complications on account of the small percentage of animal fat necessary in the cylinder oil. This in time causes the oil to become emulsified and entirely unsuitable for circulating. To remedy this trouble, there are two alternatives; the first is to dam off the space below the piston-rod stuffing box between the cylinder and the guide barrel so that the cylinder oil dropping from the rod is carried off through the bonnet drips and does not become mixed with the bearing oil; the second is to install a wiping device on the piston rod and lubricate it with bearing oil. I know that a great many engineers believe that only cylinder oil is suitable for lubricating piston-rod stuffing boxes, but we have had very good success in several instances by applying regular bearing oil in this manner.

The lubrication engineer has three alternatives to work upon in the design of a scientific system: he may install a central oiling system in which the main supply of oil is stored at one point and conveyed to the bearings of the various power units and auxiliaries by means of main feed and branch pipes to each machine; or he may make each individual engine, pump, air compressor, etc., a unit by itself, and supply it with its own oiling and filtering system; or he may provide a combination of the two by providing one lubricating system to take care of a group of machines.

In the application of the first system it is necessary to install a large part of the apparatus in duplicate in order absolutely to insure continued operation of the plant. The amount of duplication depends a good deal upon the arrangement of the plant, the susceptibility of the various parts to injury, the value of continued operation and also the ideas of the designing engineer.

To insure absolutely reliable lubrication, many plants are now installing individual oiling and filtering systems, so that each unit, from the smallest auxiliaries to the largest power unit, is equipped entirely independently of all other units in the plant. Practically everything necessary for these individual oiling systems is above the engine-room floor and therefore always in sight and under the care of the engineer or attendant.

The so-called splash system used on several makes of high-speed engines has many disadvantages. Usually the engine frame forms an oil reservoir, and the crank dipping into the oil at every revolution throws it out on the rubbing surfaces. It soon becomes saturated with small particles of metal and is entirely unsuited for use over and over again between the rubbing surfaces; furthermore, the oil, being at the high temperature of the engine frame, has practically no ability to carry off heat which may be generated in the bearings, and finally on some engines the steam leaking past the piston-rod packing and condensing in the oil reservoir soon mixes with the oil to such an extent that an emulsion is formed, which has practically no lubricating value. The proper lubrication of engines equipped with the splash system can be easily accomplished by connecting an oil supply line into the reservoir of the splash system and a dirty-oil overflow arranged so that a predetermined level of oil is maintained in the reservoir; thus the dirty oil passes out through the overflow at the same rate at which clean oil is delivered into the reservoir. In this way continuous circulation of oil is maintained and good reliable lubrication is insured. Real bearing-lubrication economy is possible only when

1 Every bearing is continually supplied with a stream of clean oil so that the rubbing surfaces float past each other on a film of oil instead of coming into metallic contact, reducing cost of producing power.
2 When the oil is automatically collected, filtered, purified for use over and over again, reducing cost of attendance and oil.

PROBABLE REQUIREMENTS IN MACHINE TOOLS

A Discussion of Means for Their Fulfilment, and a Description of an Automatic Tool-Feeding Mechanism in Which the Feed is Governed by the Driving Torque

By A. M. SOSA,[1] CINCINNATI, O.

OUR observation of the progress made in the construction of machine tools in the last twenty years shows that the development of machine tools has been accomplished by the natural process of producing or designing mechanisms to meet the requirements that were brought forth in the course of the work, and which requirements may well be divided in two classes. To the first belong those that are due to new conditions created independently of the machine itself; and to the second, those that demonstrate the evolution of the machine in itself.

CLASSES OF REQUIREMENTS

The discovery of high-speed tools brought forth the necessity of designing new gear combinations for driving the machine that would permit of a greater power input. This is a requirement of the first class. But it was observation and suggestion that has developed the modern type of quick-change gearing; and this is an example of requirements of the second class.

We aim to be ready to meet these necessities as they arise, and are prepared with systematized knowledge to solve the new problems created; but the improvements or requirements brought about through our observation and suggestion are proportional to the amount of study that we are willing to invest during the course of our daily work.

Our standards for improvements are based on the general principle of simplification of manual operations consistent with the quality of the finished product and cost of production.

Our aim is, in fact, not only to make manual operations easier, but to eliminate manual operations as much as possible. The reason is that we can perfect a machine. We can time a machine and standardize its product much better than we can the operator. And we are now satisfied by daily evidence that, at least in a mechanical sense, machines can do what men can do.

We have in modern machine tools automatic stops, power quick traverse, belt shifters, tool lifters, sizing grinders, and other numerous attachments with which we are familiar. These attachments add in each case some parts, and in some cases complicated mechanisms, to the original machine, in order to increase its output by simplifying the manual operations. The increase and dependability of the output justify the additional expense.

Each of the examples here given is of the same nature, inasmuch as its object has been to eliminate the frequent repetition of some manual operation. They all require the setting of some additional gage to reproduce a given performance, and we may well associate the above with the general study of jigs and fixtures, as their development has been hand in hand.

These accessories do not affect the standard construction or the fundamental lines of the machine to which they are applied. Changes that affect the fundamental construction are of such blended character that it is difficult to point out the different steps of the transformation. The total advance may be appreciated by comparing the modern machine with its equivalent of twenty-five years ago, and the most influential details in this advance can be attributed to the perfecting of gear wheels and their combinations.

In those days it was not permissible to feed a tool with rack-and-pinion motion nor to drive a cutter with an all-gear combination; the tooth marks were clearly visible. And it was not all the fault of workmanship, as imperfect applications of gear trains were many times the cause of such poor results.

We can say, in general, that positive transmission of motion and quick-change-gear combinations are the prominent details that characterize the modern machine tool. These gear changes are quick and simple, with very few exceptions, but there are exceptions, and besides, these are, at their best, manual operations, two good reasons for attracting our attention.

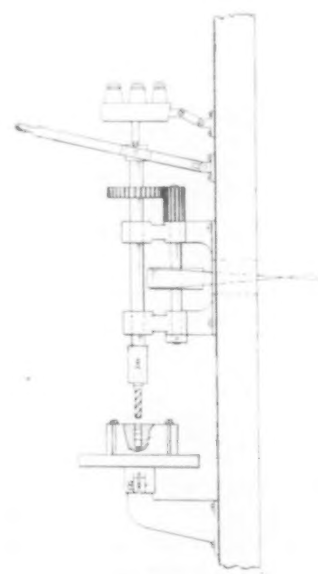


Fig. 1

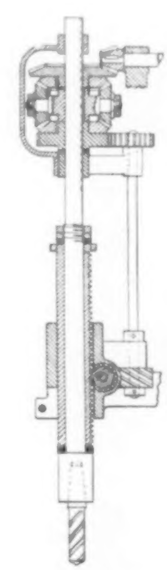


Fig. 3

FIG. 1 UPRIGHT DRILL FOR TESTING HARDNESS
FIG. 3 DRILL WITH DRIVING FORCE AND FEEDING FORCE COMPLEMENTARY

We may consequently say that the further perfecting of gear trains and their combinations, consistent with our continuous effort for saving manual labor, will bring about the modification of some of those gear changes that are now left to the will of the operator.

PROBLEM OF THE DRILLING MACHINE

As an illustration I will call your attention to one particular application, and I will select the drilling machine. Here

[1] Member Engineers' Club of Cincinnati.

Presented at a meeting of the Cincinnati Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, March 16, 1916.

the changing of tools is ordinarily very frequent. The diameter of the tool is charted with its corresponding speed in revolutions per minute. A quick change of the position of one or two levers and the proper speed is given to the tool.

But to feed this tool properly is a consideration not quite so simple. In the first place, excessive speed will not break the tool, while excessive feed will break the tool. In the second place, if excessive speed burns out the tool, the feed again will break the tool or the machine. The feed is, in both cases, the more important change of the two.

On the other hand, a drilling machine, on account of its constructive capacity, admits of two or three times as many speeds as it does feeds, for the reason that all the feed-change gears must be comprised in the head of the machine. The result is that the same feed is charted for a considerable number of tool diameters.

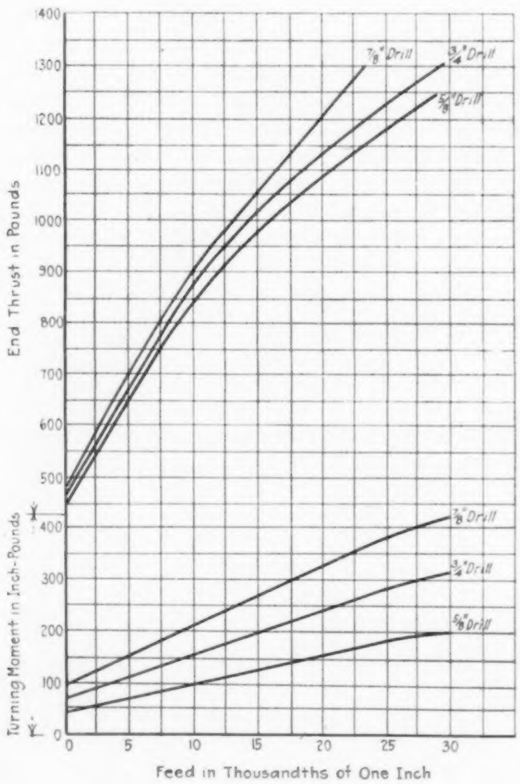


FIG. 2 RELATION OF END THRUST TO DRIVING FORCE

Another consideration is that the amount of feed given on the chart will feed the tool properly after the cut has been started and brought to full diameter without abnormal effort that would indicate that the tool is dull, and for this reason the operator will start feeding by hand previous to connecting with power feed, making certain that the tool is cutting freely, and also will finish feeding by hand in many instances to prevent a breakage as the tool comes through the metal. When using tools in connection with jigs, where said tools carry stop collars to gage depths, it is also necessary to feed by hand against such stops. Consequently, the operator, after making the necessary feed changes, will feed by hand the greater part of the time in many instances.

The conclusion is that the power feed in such a machine does not meet all of the requirements, being more a hand than a power-operated mechanism.

These limitations of the feed gearing are not characteristic of the drilling machines alone, for other machine tools will be found wanting in similar respects if carefully examined.

Now, if we are to continue perfecting gear transmissions, this most likely will be the nature of the requirements that we will have to meet in the near future.

That it is possible to accomplish the desired results there is no doubt in our minds. Nevertheless, as an example, I will suggest an analysis and a possible solution of a plain train of positive gearing to feed the tool in drilling machines that might be considered a step in the right direction in the development of feed gearing.

ANALYSIS OF DRILL-FEEDING PROBLEM

Fig. 1 represents the elements of an upright drill as it is used for testing the hardness of materials. The spindle is driven in a normal way. Provision is made for the application of a given weight to the spindle of the machine. Here, for a given weight and a given speed, the materials under test for hardness are graded by measuring the penetration of the tool in a given time. Tests of this kind have been published in the *American Machinist,* and are quoted here only to substantiate the fact that the tool can properly be fed by a constant pressure. The feeding of drills is at present accomplished by positive motion.

Fig. 2 gives in condensed form the results of numerous tests for determining the values of the end pressure needed to feed the tool,[1] and the torque required to drive the same tool.[2] The values of three tool diameters are given: 5/8 in., 3/4 in. and 7/8 in. There are two curves given for each side, one for the value of the end pressure or thrust, and one for the value of the turning moment or torque. The upper curves, for end pressure, read pounds on the vertical scale corresponding to feeds on the horizontal scale in thousandths of an inch. The lower curves, for the turning moment, read pounds at one inch radius on the vertical scale corresponding to feed in thousandths of an inch on the lower scale. For example, the end thrust required to feed a 5/8-in drill with an 0.011-in. feed is 875 lb., and the torque required to drive it is 100 in.-lb.

The driving force and the feeding force are so related in the actual action of cutting that the one cannot exist without the other; in other words, they are two component forces, and their values are functions of each other. These values, as given in Fig. 2, vary in the same direction, but not proportionally, as may be seen by the relative obliquity of each two curves for the same diameter of tool. It will be seen that as the feed increases the end pressure increases more rapidly than the turning moment.

Fig. 3 shows an elementary construction of a drilling machine where the driving force and the feeding force are complements of each other. This is a differential gearing such as is used on the rear axle of an automobile, and whose construction and efficiency are well known.

PROPOSED DIFFERENTIAL GEAR FEED, IN WHICH THE ADVANCE IS GOVERNED BY THE DRIVING TORQUE

A small bevel pinion is our source of power, this driving a double bevel gear running loose on the spindle. Meshing with the lower half of the double bevel gear are two bevel pinions running loose on trunnions that project from a sleeve; this sleeve driving the spindle by means of a sliding key. These bevel pinions are called planet pinions, and meshing with

[1] Thrust of Twist Drills, H. Hess, Am. Mach., 1907, p. 598.
[2] Power Required to Drive Twist Drills, Frary and Adams, Am. Mach., 1907, p. 210.

them is another bevel gear, called the supporting gear, around which the planet pinions will roll when driven by the first driving gear. The supporting gear also runs loose on the spindle, together with a spur gear, which is the first member of the feed train of gearing. A vertical shaft, two spiral gears, and a rack and pinion complete the feeding mechanism.

The said supporting gear is positively geared to the spindle for feeding. Its motion is proportional to the feeding movement of the tool, and if the tool does not advance this gear will not turn. The said driving sleeve is carried around by planet pinions at one-half the speed of the first driving gear as long as the supporting gear does not turn, but as the speed of the supporting gear, when the tool is feeding, is very low, it only affects the spindle speed on a very small percentage.

The planet pinions exert a tooth pressure on the supporting gear equal to one-half the pressure effective on their trunnions, measured on a radius equal to the pitch radius of the supporting gear. This pressure is transmitted through the feed train of gearing down to the end of the tool. The amount of tooth pressure on the supporting gear and the amount of end pressure on the tool, or, the ratio of these two pressures, depend on the gear ratio of the feed train of gears. The pitch radius of the supporting gear multiplied by its tooth pressure equals the turning moment given in Fig. 2. The tooth pressure of the supporting gear multiplied by the feed-gear ratio equals the end pressure given in Fig. 2.

This mechanism, fitted with the proper feed-gear ratio, will, in driving the spindle with a given torque, produce the necessary end pressure to feed the tool just enough to maintain the said torque. These two forces, the driving force and the feeding force, are functions of each other, and it is necessary that they come to be in equilibrium at the desired rate of feed in order to maintain the feed constant.

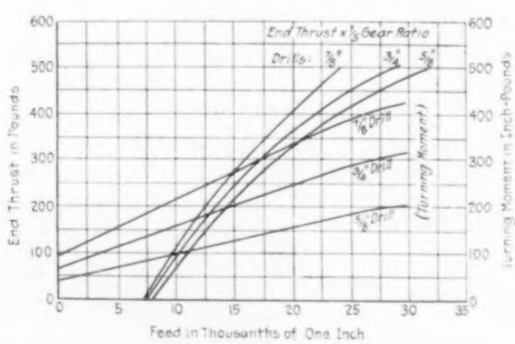


FIG. 4 RELATION OF END THRUST TO FEED-DRIVING FORCE. END THRUST REDUCED BY GEAR RATIO OF 5:1

Fig. 4 is a modification of Fig. 2. The turning moments are the same as before, but by introducing a feed-gear ratio of about 5 to 1, the values corresponding to end thrust are reduced by a factor of 5. The curve for end thrust in this diagram represents the force inside the differential gear which, multiplied by the feed-gear ratio, will produce a force five times greater to feed the tool. A factor was selected high enough to permit the lines of the end thrust to intersect the lines of the turning moment. As the feed increases the two lines that correspond to the given diameter advance until they intersect. The point of intersection represents the amount of feed reached when the two forces come to be in equilibrium.

With the gear ratio assumed in the present example, a 7/8-in. tool will reach 0.015 in. feed and maintain 0.015 in. feed thereon; a 3/4-in. tool will reach 0.013 in., and a 5/8-in. tool will reach 0.011 in. feed.

Fig. 5 represents the head of a radial drill mounted on the arm of the machine. Only the details that pertain to the present subject are shown, and these again in a very elementary form.

The horizontal shaft, inside the arm, through bevel gears, not shown, drives a second horizontal shaft at right angles. This second shaft carries another bevel gear which meshes with the two bevel gears shown near the bottom of the figure. A clutch between these two gears serves to drive the vertical shaft in either direction. From here on the gearing for driving and feeding the spindle is the same as in Fig. 3, except that the supporting gear is placed above the planet pinions and the driving gear below, for convenience only. The reversing clutch will change the direction of rotation of the whole train of driving and feeding gears.

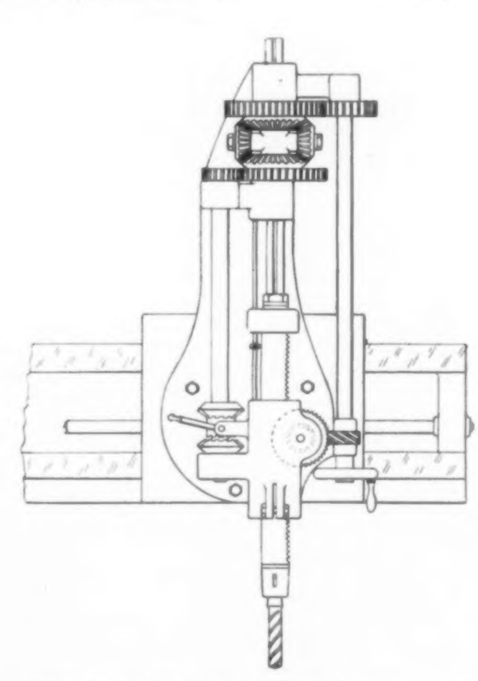


FIG. 5 DRILL WITH AUTOMATIC FEED GOVERNED BY DRIVING TORQUE

The reversing-clutch lever has two positions that correspond to the upward and downward movement of the spindle. It is operated by hand or is tripped by a collar on the spindle, striking an adjustable dog on a vertical rod, shown in a parallel disposition to the spindle. Said vertical rod is arranged to throw the clutch into the reversing position automatically, so that, if the tool is at work and the reversing clutch is tripped, the tool will withdraw from the work, and will do so whether the tool is a drill or a tap. If, on the other hand, the clutch is thrown in, the tool will advance until striking the work.

It will be noticed that the idle movement of the spindle, before the tool strikes the work or after reversing, will be a rapid movement. It will also be noticed that the hand wheel shown on the right-hand side is operative at any time and whether the tool is under cut or not, except in the case of a tap, when the reversing clutch must come into action. It will also be noticed that stop collars on drills will be effective when feeding by power. Could this mechanism be realized, the result would be a machine without feed consideration, as far as the operator is concerned.

METALLIC ALLOYS, WITH PARTICULAR REFERENCE TO BRASS AND BRONZE

By WILLIAM M. CORSE,[1] NIAGARA FALLS, N. Y.

Law defines an alloy as "a coherent metallic mass produced by the intimate mixture, whether by fusion or otherwise, of two or more metals or metallic substances." Our world is composed of about one hundred elements, of which approximately fifty are metals. Of these metals about thirty are in everyday use and less than fifteen to any great extent. As an alloy may consist of two or more metals, we can see what a large number of combinations are possible. There are many pairs of metals that have never been alloyed, so the possibilities for research are almost limitless.

Before taking up the better-known metallic alloys such as brass and bronze, let us glance at some metals which are now passing from the rare into the common class.

Cobalt is a metal similar to nickel in many respects but has properties which it confers on its alloys that are distinctive.

Chromium is commonly known as an ingredient of some steels and in combination with cobalt forms stellite, an alloy which has quite recently helped out during the shortage of tungsten.

Tungsten is well known now both in high-speed steel and in the tungsten-filament electric lamp.

Calcium is a metal not produced as yet in large quantities, but as a hardener for lead has recently attracted attention. It will harden lead about ten times as much as antimony, which is commonly used for the purpose. The manufacture of shrapnel bullets stimulated this use.

Magnesium is now a commercial product finding its use principally in light alloys.

Vanadium is another metal used in alloy steels and in some bronzes.

Silicon in 1900 was a curiosity but is now produced at Niagara Falls in large quantities.

Titanium is, next to iron, the most abundant metal in the earth's crust. It principal use at present is as ferro-carbon-titanium, which is used as a cleansing agent in steel. It is also used in bronze alloys and its oxide as a white pigment.

Cadmium, thallium, molybdenum, and *boron* can be produced cheaply and are awaiting their extensive practical uses.

Copper, tin, lead, zinc, aluminum, and antimony are the most useful of the non-ferrous group. The metals alone have many uses, but the field is widened when metallic alloys are produced.

Copper and tin with copper above 80 per cent form the true bronzes. Other metals added confer special properties but the dominating feature of the alloy is the copper-tin base. Lead, for example, is added to aid in machining and zinc to promote soundness.

Copper and zinc with copper above 56 per cent form the true brasses. These also are modified by the addition of a third or fourth metal such as tin or lead, but still possess the properties of the basic copper-zinc combination in the particular proportion specified.

For some reason the term bronze is also applied to other combinations than copper-tin alloys; for example, manganese bronze. This is a copper-zinc alloy approximately 60 per cent copper and 40 per cent zinc, to which a hardener, consisting principally of iron, is added. Aluminum bronze is another example; it is an alloy approximating 90 to 95 per cent copper and 5 to 10 per cent aluminum.

Alloys consisting principally of tin or lead to which other metals such as antimony and copper have been added as hardeners, are known as babbitt metals.

Alloys have been known for hundreds of years but their scientific study has been undertaken only during the past twenty-five years. This period has been marked by several distinct phases of development:

1 The advent of the chemist and metallographist into the trade
2 The exchange of information through trade journals and scientific societies. The oldest trade journal was started in 1902 and the two scientific societies, viz., The American Institute of Metals and The Institute of Metals of Great Britain, were founded in 1907 and 1909, respectively
3 The application of knowledge gained to engineering problems and shop methods both from a manufacturing and consuming viewpoint.

These three phases enabled information pertaining to the industry to be widely disseminated, and the exchange of knowledge has led to many permanent advances and made possible many developments; for instance, aluminum is now a commercial article; magnesium, tungsten, titanium, and vanadium are well known and have important uses. The methods employed in studying alloys have been conveniently classified by Roberts-Austen and Stansfield[1] under

1 The chemical grouping of the metals in a solid alloy
2 The separation of the constituents during solidification.

The first of these includes the methods of investigating their specific gravity, electrical resistance, diffusion, electrolytic conduction, thermo-electric power, heat of combination, electromotive force of solution, also the isolation of constituents by chemical methods, and microscopic examination.

The second group deals with those methods involving a study of the separation of the constituents of an alloy on solidification, and includes measurement of fall of temperature during solidification by means of a pyrometer, mechanical separation of the constituents of an alloy by heating to definite temperatures and draining off or pressing out the liquid portion, and investigation of the changes in the magnetic character of certain alloys during heating and cooling.

The methods thus outlined have given valuable results, but according to Gulliver[2] the most fruitful results have been obtained by considering alloys as solutions of metals in each other and studying them by means of the thermometer or pyrometer, and the microscope. The record of temperature gives the melting point, freezing point, and critical temperatures of the alloy; the microscope shows its structures; and these two determinations taken in conjunction reveal very valuable data.

The microscopical study of metals and alloys is known as metallography. In this connection it may be mentioned that

[1] The Titanium Alloy Mfg. Co.

Abstract of paper presented at a meeting of the Buffalo Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, January 31, 1917.

[1] Law, Alloys, p. 39.

[2] Gulliver, Metallic Alloys, 2d ed., p. 1.

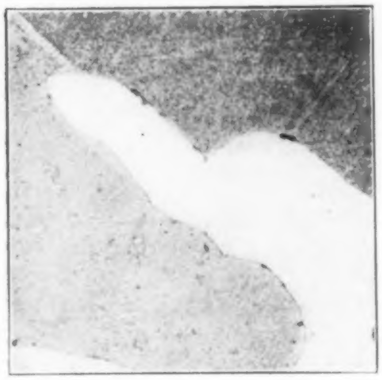


Fig. 1 Magnified 100 Diameters

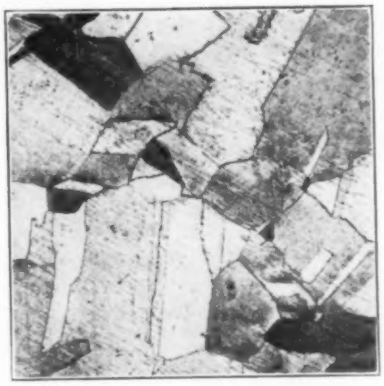


Fig. 2 Magnified 100 Diameters

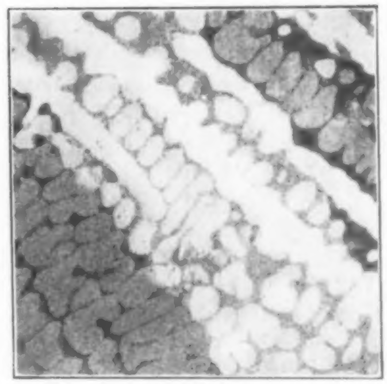


Fig. 3 Magnified 100 Diameters

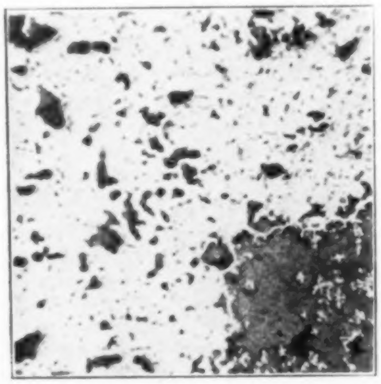


Fig. 4 Magnified 20 Diameters

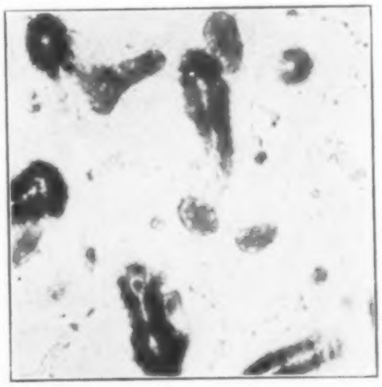


Fig. 5 Magnified 200 Diameters

Fig. 6 Magnified 400 Diameters

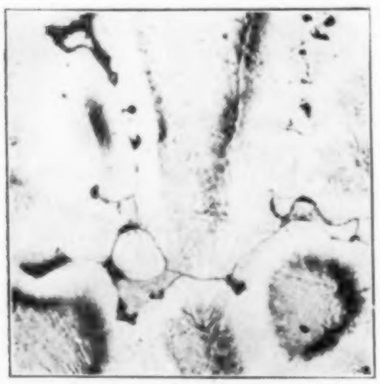


Fig. 7 Magnified 400 Diameters

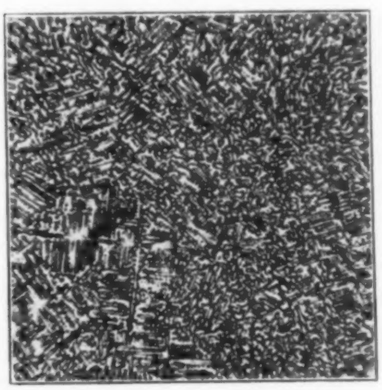


Fig. 8 Magnified 20 Diameters

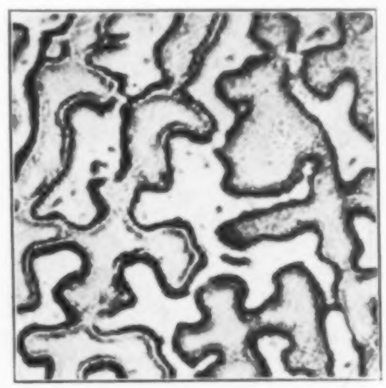


Fig. 9 Magnified 200 Diameters

Fig. 10 Magnified 200 Diameters

Fig. 11 Magnified 200 Diameters

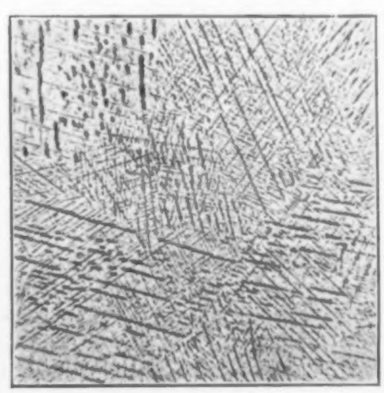


Fig. 12 Magnified 20 Diameters

Figs. 1 to 12 Photomicrographs of Typical Bronze Structures

the reports of the Alloys Research Committee to the Institute of Mechanical Engineers of Great Britain are splendid examples of this kind of work and stand as enduring monuments to their authors.

The tensile strength, yield point, elongation, and reduction of area are determined on a machine of the Olsen or Riehlé type and the hardness determined wherever possible by the Brinell method. The latter consists of forcing a 10-mm. steel ball into the surface of the metal under constant pressure and measuring the diameter of the depression. By referring to a table the corresponding hardness number is found. The scleroscope is also used, but the results are not as dependable as those found by the Brinell method.

Fatigue-testing machines such as the White-Souther give valuable results in special cases. For example, the resistance to fatigue or vibration of titanium-aluminum bronze was found to be about ten times that of manganese bronze, both bronzes being of equal strength. Machines to determine wear have been devised but not as yet widely adopted. A good machine of this kind would be very valuable.

One of the questions frequently asked in engineering circles is, how the ancients tempered copper. Various attempts have been made from time to time to claim the discovery of this lost art but without much success. The facts are that the tempered copper of the ancients was an alloy and not a pure metal. The chemist has shown us that it contained iron and tin in sufficient quantities to harden the metal. The main difference between ancient and modern metallurgy lies in the purity of the metals produced. The ancients really made alloys instead of pure metals, and secured the corresponding properties of alloys while assuming that what they handled was pure metal. While this fact has been known for a long time, the slow dissemination of metallurgical information gives ample opportunity for the country drug store to produce several discoveries of this lost art annually.

While it is generally known that small amounts of certain elements such as carbon, phosphorus, and sulphur exert a profound influence on the properties of steel, it is not as generally known that small amounts of certain elements such as oxygen, sulphur, vanadium, titanium, and phosphorus also exert profound influence on the properties of certain nonferrous alloys.

The study of the metals in the bronze foundry is a larger proportion of the scientific work to be done than the same study in the iron or steel foundry. The iron foundry has but a few grades of metal to make, while the brass foundry or casting shop may have a hundred standard formulæ for alloys and several times as many for special cases. Each alloy requires the thought and attention of the man in charge. The importance of the study of metallic alloys, I am quite sure, will furnish sufficient work for years to come.

I should also like to mention the need of coöperation between the metallurgist and the engineer. Instances of lack of knowledge on alloys come up every day. For example, a large railway recently specified an alloy of copper 58 per cent, tin 40 per cent, zinc 2 per cent. We inquired the need for such an alloy and received the reply that the service of the part in question demanded a hard metal, and in an effort to find one a consulting engineer was asked to suggest a formula. The suggested alloy is certainly hard, but it is so brittle that if the casting were allowed to drop on the floor it would break into a hundred pieces. Twenty per cent tin in that alloy would have been about the limit.

Another point to be emphasized is the difference which exists between results of test bars and the properties of the casting itself. Design, relation of thick and thin sections, and weight all have a very direct bearing on the result. Many engineers do not possess data on the relation between the strength of the test bar and the strength of the casting. Although the matter has been the subject of a few articles, it will bear repeating, as many misunderstandings arise through a lack of knowledge of this relation. I know there is a wide discrepancy between the two, but do not have sufficient information as yet to warrant the formulation of a rule. I want to mention the fact so that engineers will recognize that the condition exists, and they will be willing to coöperate in getting more data on the subject.

The illustrations are given to bring out the need of coöperative advice and show the sort of problems that arise. These can only be solved by the application of scientific methods and the appreciation by both manufacturer and consumer of the necessity for coöperative work and study. That the field of alloys research is of interest is not questioned by those who have worked in it, and it will only be necessary to present the matter in the proper light to convince engineers of its practical value.[1]

ILLUSTRATIONS

Fig. 1 shows the structure of pure cast copper of high electrical conductivity magnified 100 diameters. Parts of large uniform crystals are shown, the different crystals being of different shade because this metal has been etched with ammonia and peroxide, which attack some crystals more than others, depending on the way the polished section happened to cut the various crystallographic axes. This structure is typical of all pure metals; the only impurities seen here are the few small black spots, which are probably traces of oxide.

Fig. 2, shows this same material at the same magnification after forging. The crystals are very much smaller, and many of them show more or less parallel bands, evidence of the phenomenon known as *twinning*. Although this is a view of forged pure copper, the structure is perfectly typical of all hot-worked pure metals or solid solutions, such as rolled brass, for instance.

Fig. 3, at the same magnification shows the structure of copper cast carelessly, without deoxidation. Melted copper dissolves oxygen from the air very readily in quite large amounts, but when this oxidized copper solidifies on cooling, the cuprous oxide is thrown out of solution, forming a mixture with the metal called an eutectic. This eutectic is shown clearly in this figure as a dark substance filling the spaces between the rounded grains of copper. It is a weak, brittle substance, and spoils the ductility of the metal. The copper crystals are shown here of different shade as in the previous figures, on account of the action of the etching reagent, as explained before, but in both the light-etching and dark-etching copper crystals the oxide eutectic is etched darker than the copper.

Fig. 4, in which the structure is magnified 20 diameters, shows copper containing lead instead of oxygen, and this metal was not etched, so that the copper crystals are not shown. Lead is so much softer than copper that it wears away to a lower level in polishing and does not take as good a polish as copper, so that it always looks dark in a polished section through the microscope. The dark spots here are lead and the bright background is copper. Metal like this is used for soft bearings that must give good service at very high speeds, and not become hot even if lubrication is not always effective. Since copper and lead do not dissolve in each other even when melted, it is hard to cast a uniform mixture of the two, and it takes care and skill to avoid the occurrence of large globules of lead, one of which is shown in part in this figure, and which might so weaken the casting as to cause it to break. An interesting feature of this figure is the presence of very small star-shaped crystals of copper, somewhat like snow crystals, in the large globule.

Fig. 5 is a view of a leaded bronze, or an alloy of copper, tin and lead. This metal has been etched, and the structure is shown

[1] I wish to thank Mr. George F. Comstock for his able coöperation and for the photomicrographs which accompany this paper.

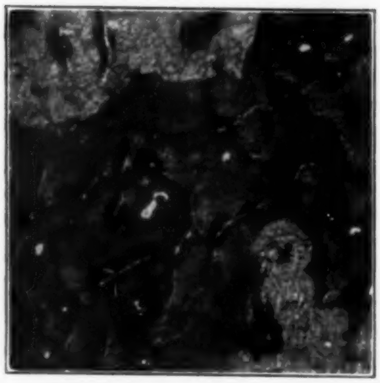


FIG. 13 MAGNIFIED 200 DIAMETERS

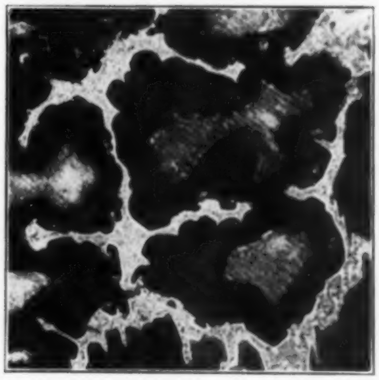


FIG. 14 MAGNIFIED 200 DIAMETERS

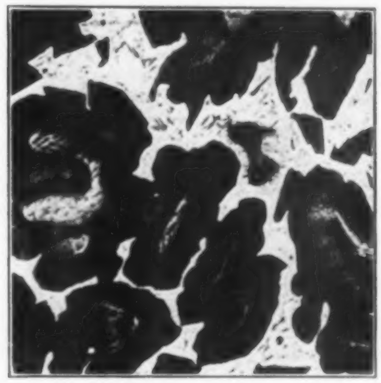


FIG. 15 MAGNIFIED 200 DIAMETERS

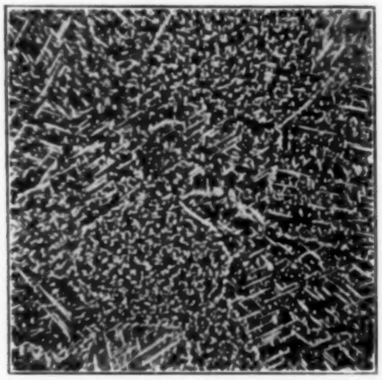


FIG. 16 MAGNIFIED 20 DIAMETERS

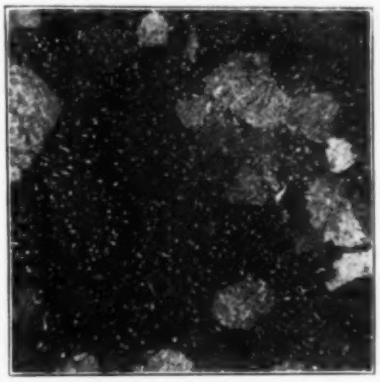


FIG. 17 MAGNIFIED 20 DIAMETERS

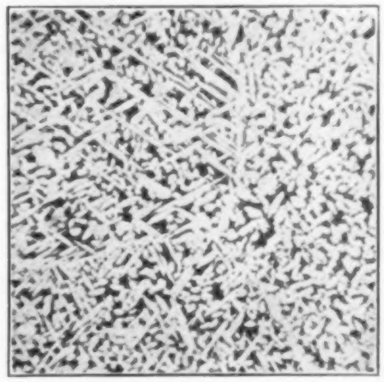


FIG. 18 MAGNIFIED 20 DIAMETERS

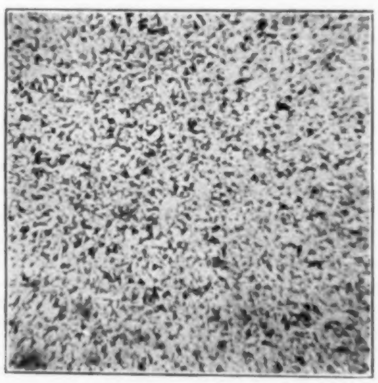


FIG. 19 MAGNIFIED 20 DIAMETERS

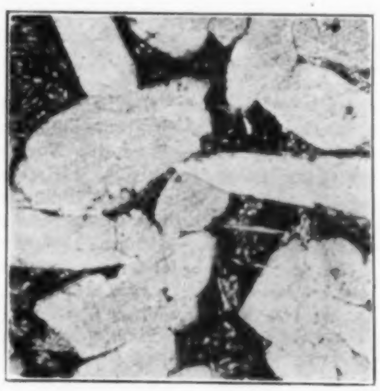


FIG. 20 MAGNIFIED 400 DIAMETERS

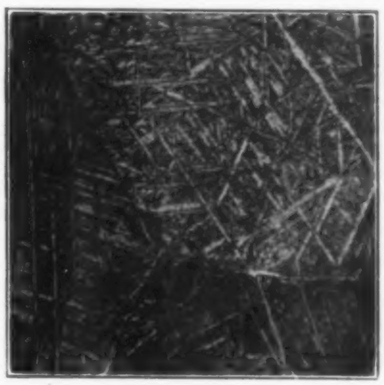


FIG. 21 MAGNIFIED 200 DIAMETERS

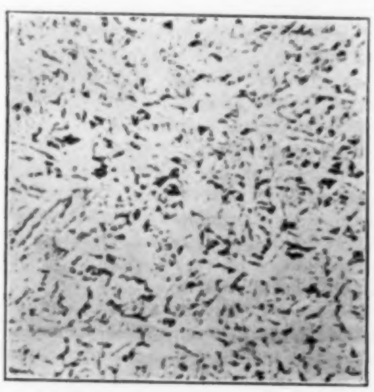


FIG. 22 MAGNIFIED 200 DIAMETERS

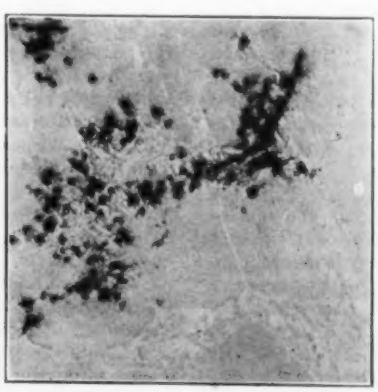


FIG. 23 MAGNIFIED 200 DIAMETERS

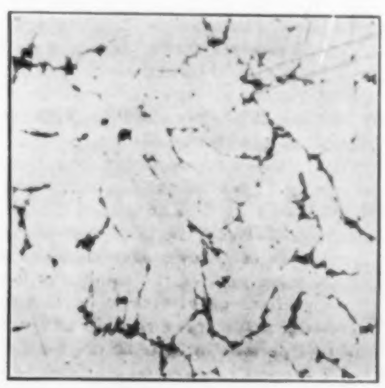


FIG. 24 MAGNIFIED 50 DIAMETERS

FIGS. 12 TO 24 PHOTOMICROGRAPHS OF TYPICAL BRONZE STRUCTURES

magnified 200 diameters or ten times as much as in Fig. 4. Here two other features are shown, on account of the presence of tin in the alloy. The rough-looking black spots with bright centers are not lead, but the soft cores of the bronze crystals, which, being lower in tin than the rest of the metal, were eaten away by the etching reagent, while the parts higher in tin were left bright. The soft cores, low in tin, are found in all cast bronzes, because when bronze first solidifies in cooling from the melted condition the first metal to freeze is nearly pure copper, the tin remaining as long as possible in the liquid part. When cooled so far that the last bit of the alloy must freeze, there is so much tin left in the metal that remained liquid longest, that a new constituent, high in tin, is formed. This constituent is shown in this figure as bright irregularly spotted areas, sharply outlined. These areas are bluish-gray in color, contrasting quite strongly with the yellow color of the other bright parts of the alloy. The gray constituent is known as the copper-tin eutectoid and is hard and brittle. The lead in this alloy appears as dark-gray rounded spots. It makes the metal more easy to machine and gives better bearing properties.

Fig. 6 shows at a magnification of 400 diameters a bronze containing 10 per cent tin and 2 per cent zinc, with little lead. The eutectoid is clearly seen here, and the cores are very distinct. The parts that seem to be at a lower level are the soft, low-tin parts of the crystals which were attacked by the etching reagent and dissolved away from the originally smooth polished surface. The parts standing up in relief are higher in tin and resisted the attack of the etching solution.

Fig. 7, also magnified 400 diameters, shows an alloy of the same general composition as the last one, but of poor quality. There is hardly any eutectoid shown here, but instead there are numerous black lines and spots. These are films of tin oxide, which destroy the strength and ductility of the alloy. They show that the metal was not completely deoxidized when cast: in good bronze these films should not be found.

Fig. 8 shows the appearance of a polished and etched section of a soft bearing bronze, with only about $6\frac{1}{2}$ per cent tin, and a little lead and zinc magnified only 20 diameters. Here the only thing shown is the arrangement of the soft cores of the crystals, and this dendritic or pine-tree structure is typical of nearly all cast bronzes.

Fig. 9 shows the alloy of Fig. 8 magnified 200 diameters. The harder bright portions stand out clearly above the softer cores, and contain a few traces of the eutectoid and a few spots of lead. The good bearing qualities of this metal are probably due in large measure to the irregular alternation of hard and soft streaks on any given surface. On a bearing the hard streaks would carry the load, and the soft streaks in wearing away would form microscopic channels facilitating the distribution of oil.

Fig. 10 shows the same alloy, magnified the same amount as in Fig. 9, but in this case the sample was chilled quickly in casting instead of being cast in sand and slowly cooled. The finer grain caused by chilling is apparent, and also the soft cores are more extensive, at the expense of the hard bright portions, but otherwise the structure is the same.

Fig. 11 is an extremely coarse-grained gear bronze, of English manufacture, with about 10 per cent tin and a little lead and zinc. This section is magnified 200 diameters like the last two, and also etched in the same way. The soft cores appear as large black streaks, and the spotted structure of the eutectoid is clearly seen. This bronze would be hard to machine, on account of the learge spots of hard material in it, which would dull the point of the tool.

Fig. 12 shows a similar bronze with 11 per cent of tin, etched in the same way and magnified 20 diameters, but cast in a chill. The very fine grain as shown here can be easily and certainly produced by chilling this alloy, and is far superior to a coarse structure from all points of view.

Fig. 13 shows a sample cut from the chilled face of a bronze gear containing 11 per cent of tin, magnified 200 diameters, or ten times as much as Fig. 12, and etched differently, so that all the surface is darkened except the hard high-tin eutectoid. The soft cores of the crystals are shown here as black streaks with bright centers, but the main part of the alloy was darkened by ferric chloride to give a greater contrast between it and the bright eutectoid. The interesting point about this structure is the very small amount of eutectoid present in spite of the high tin content, and the result is that this metal is easy to machine and still hard enough to make a good gear. Such a structure is produced merely by chilling the metal as soon as it is cast.

Fig. 14 shows the same metal, etched and magnified in the same way, but slowly cooled in casting. The large amount of eutectoid here makes the metal brittle and hard to machine. The soft cores in this alloy are so coarse that their centers form rather large light areas, but the eutectoid is much brighter and of more irregular shape.

Fig. 15 shows the structure of a harder gear bronze, with 13 per cent tin and 2 per cent zinc, sand-cast, and etched and magnified 200 diameters. There is still more eutectoid here, and its spotted structure is clearly brought out. Bell metal has only a little more eutectoid than this.

Fig. 16 shows the structure of a rather coase-grained and soft manganese bronze, magnified 20 diameters. The metal when just solid in cooling from the liquid state consisted entirely of the dark constituent; on further cooling the bright needles separated out along the cleavage planes of the original crystals. The different original crystals may thus be distinguished, not only by the color assumed in etching, but also by the directions of the bright needles in them.

Fig. 17 shows a fine-grained, harder and stronger manganese bronze, etched and magnified in the same way. This metal was cooled faster in casting, and the bright needles did not have much chance to develop before the temperature dropped too low for any further growth.

Fig. 18. Another non-ferrous alloy which has strength and ductility comparable with manganese bronze and steel is aluminum bronze, a name applied to alloys of copper with up to 10 or 12 per cent aluminum. The structure of a typical 10 per cent aluminum bronze, cast in sand, and magnified and etched in the same way as the previous views of manganese bronze is shown here. This alloy is seen to be normally coarser grained than manganese bronze, and to have more of the light constituent, which is softer, and less of the dark constituent, which is harder. Consequently its yield point is lower than that of manganese bronze, but its ultimate strength and ductility are just as good, and in endurance or resistance to fatigue, and in bearing qualities, it is far superior. It also resists corrosion very well.

Fig. 19. We have found that the addition of iron to aluminum bronze refines the grain very decidedly, and gives a higher yield point and slight improvements in other properties except the resistance to corrosion. Here is shown the typical structure of an alloy of copper with 10 per cent aluminum and 4 per cent iron, magnified and etched as in Fig. 18, the distinctive characteristics being the fine grain and absence of the long parallel needles always seen in ordinary aluminum-bronze castings.

Fig. 20 shows the structure of a good sand-cast sample of 10 per cent aluminum bronze etched as before but magnified 400 diameters. The dark constituent is here seen to be of duplex composition, containing light and dark particles. This in fact is a eutectoid similar to the one seen in the tin bronzes, but it etches dark instead of light.

Fig. 21. Aluminum bronze shares with steel the property of hardening in quenching, with the formation of a peculiar martensitic structure, as shown here. This structure was produced by heating a small piece of 10 per cent aluminum bronze to 900 deg. cent. and quenching it rapidly from this temperature in cold water. This is magnified 200 diameters. Such metal as this is strong, often taking over 100,000 lb. per sq. in. to break it, but has no ductility. It has a hardness of about 200 Brinell. As in the case of steel, a double heat-treatment consisting of quenching followed by tempering gives superior qualities.

Fig. 22 shows a structure obtained by reheating a quenched 10 per cent aluminum bronze to a dull red heat and cooling slowly. The structure is shown magnified 200 diameters and is much finer than is ever obtained in an untreated casting. This metal has a high yield point and a high ultimate strength, with over 10 per cent elongation and very great resistance to fatigue.

Fig. 23. The casting of aluminum bronze is especially difficult because of the easy formation of oxide of aluminum in the metal and the great difficulty of removing it afterward. This figure shows some inclusions of aluminum in aluminum bronze, magnified 200 diameters and not etched. It takes special care and the use of special fluxes to prevent the occurrence of such inclusions in all alloys containing notable quantities of aluminum.

Fig. 24 shows the typical structure of the light alloys, composed largely of aluminum, magnified 50 diameters. This particular alloy contained 8 per cent of copper, and its polished surface was etched to darken the copper-aluminum eutectic, leaving the nearly pure aluminum crystals bright. The eutectic is very brittle, but much harder than aluminum, so that although this alloy has hardly any ductility, it is harder and stiffer and a little stronger than the purer metal would be.

GRAPHICAL CONTROL ON THE EXCEPTION PRINCIPLE FOR EXECUTIVES

By FRANK B. GILBRETH, PROVIDENCE, R. I.

Member of the Society

We have stated many times that the greatest waste in the world today is from unnecessary, inefficient and ill-directed motions. Many people think that this statement refers only to such activities as those of the bricklayer, the shopworker and other kinds of mechanics and manual workers. It does refer to them, but by no means to them only. It refers to the activity of every one and, by no means least, to that of managers and all other executives.

To one trained in the sciences of management and motion study, nothing is more ridiculous and pitiful than the average executive when he tries to enforce new motion methods on those farthest below him in the industrial scale, while he at the same time commits nearly all the motion wastes in his own personal work. The personal work of the executive should consist as much as possible of making decisions and as little as possible of making motions. General recognition of this fact has resulted in the common practice of assigning to the executive one or more secretaries, or clerks, to relieve him of certain parts of his work which involve mere motions and less important decisions than that part of the work retained by the executive.

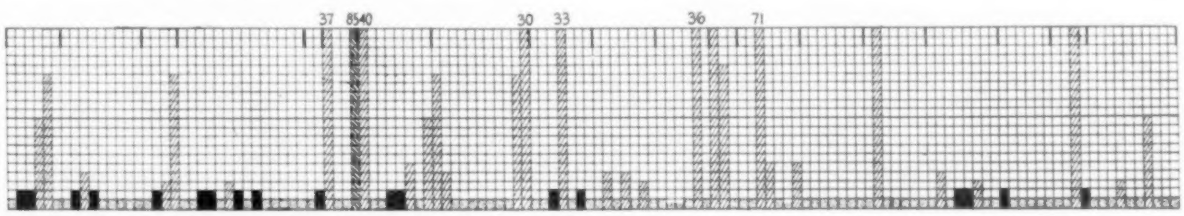


Fig. 1 Simple Illustration of a Chart Used on the Exception Principle

Such a chart may, for example, show the promptness of performance of an information bureau of a factory in charge, say, of trade publications, estimates of work under consideration, and records of design sketches. Each horizontal space may represent a specific request for information and each vertical space the time required to supply it. Colors may be used to indicate notable time differences. The point of the exception principle is that the chart shows at a glance when it took too long for a definite inquiry. Then it may be the duty of one individual to ascertain why, for instance, as long as 10 min. was necessary and another when the time is, say, over 20 min. In the so-called three-position plan of management (in which the occupant of any particular job gets supervision from the one promoted from it and serves as a tutor to one in line to fill it), the result is an effort to keep the time intervals within the safety zone, so to speak, so that No. 1 of the three-position plan is not likely to be demoted to improve the service.

INFORMATION A SATISFACTORY CHART SYSTEM SHOULD AFFORD

Some executives are furnished with charts which show by means of comparable curves the increase or diminution in outputs, costs, overhead expenses and, in comparatively rare instances, even in results as compared with budgets. As compared with an organization which has no cost system, such a recapitulation even in the form of an "expenditure system" and such cost statements and graphical charts are a great step forward. No cost system nor chart system, however, can be considered really satisfactory unless it fulfills the following requirements; i.e., it must determine and show—

1 What the quantities of individual outputs should be (prophecies of outputs)
2 Prompt records of individual outputs
3 What the costs should be (prophecies of costs)
4 Prompt records of costs
5 Causes of fluctuations and deviations of outputs and costs from prophesied outputs and costs.

The executive may have much to do with originally determining items 1 and 3; but after the computations of 1 and 3 have been completed, he can best attack the problem of enforcing items 2 and 4 and, also, of determining 5 by the use of graphical charts. He should be provided with charts which will tell him how promptly such records of output and cost have been made; or, in other words, how much time has elapsed between the completion of the output and the recording of it and its attending costs.

A long experience has shown us that the by-products of a properly operated chart system are even more valuable than its direct product. We find that the psychological effect of the variable "promptness" itself makes the curves representing outputs and costs fall more nearly in the proximity of the established norms and locations prophesied on the charts. Such charts give the executive and his colleagues accurate measured information of deviations from class in all departments. The motions that an executive would expend in getting information by such old methods as, for example, walking through the works to see with his unreliable eyes conditions which are not typical, partly owing to his presence, bring results of little value compared with the results that can be obtained by the same amount of time and motions concentrated on those facts and conditions which cause the great fluctuations from the desired output.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 1916.

It is obvious that the foreman, or other functionary, should see *promptly* all the records of output in his particular department after they are achieved. In most cases he will be able to handle his duties still more satisfactorily if he, also, sees the costs of the outputs of his department. The time of the over-foreman, however, who may have several foremen and departments under him, is too valuable to have him, also, examine with care *all* the records of all the men under him. Consequently, he should be furnished with information in concise form, in order that as little as possible of his time may be taken. This has often been furnished him in the form of "averages."

USE AND VALUE OF PROGRESSIVE AVERAGES

Ordinary averages have their use. Progressive averages are, however, more valuable, because they show the trend of

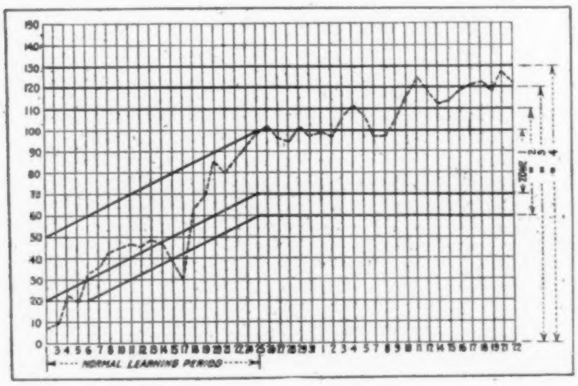


FIG. 2 EXAMPLE OF EXCEPTION-PRINCIPLE CHART COVERING OUTPUT OF AN INDIVIDUAL, INCLUDING LEARNING PERIOD

In this chart zones are established so that points of performance falling below or above certain limits come automatically by that fact to the attention of certain individuals. The lower the record or the higher the record the higher in the industrial-management scale will be the individual who must inquire into the conditions. The results may indicate poor instruction or incompetency in foremanship or they may bring the executive into personal contact with the worker in the matter of commendation for unusually high performance.

progress and of efficiency. It sometimes pays to make ordinary averages, but the value of examining such ordinary averages is slight compared with the benefits which result from concentrating the same amount of motions and attention on those individual cases that brought the average away from the ideal. A case of "bad average" may be the excuse for "putting the foreman on the carpet," but the results of this do not compare with the good results that are derived from having the over-foreman investigate promptly the case or cases that spoiled the average.

Moreover, the decisions of the over-foreman can be made more quickly, for he has the information which comes from locating the trouble accurately. Instead of "tearing out" the foreman or the workmen, he will find, from the causes marked on the chart, that the worker's low output is due to lack of the proper tools; to his not having been furnished with tools in standard conditions; to the routing system having failed to give him proper materials in the right quantities, in the right sequence, at the right time; to something which has gone wrong with the equipment or surrounding conditions; to the man's not having been properly instructed; to there having been an unwise selection of the man or the machine, or both, for the particular job.

The worker, also, is more careful not to do anything which is not expected of him, because he knows that the exception will surely be noticed by the executives higher up and will interfere with his chances for promotion or transfer to work of a more desirable kind. Knowing that they will be investigated properly will create a tendency on the part of the foreman and the workers to coöperate with others whose work affects theirs, or who in turn may be investigated. This coöperation becomes general, and sooner or later becomes a habit.

OPERATION OF THE EXCEPTION PRINCIPLE

Now the time of the executive next above the over-foreman is still more valuable than that of the over-foreman, and so on up to and including the managing director or president. No executive should make a routine motion of handling, turning over or examining charts containing data, either normal or with considerable deviation from class, where the causes of the deviation can be handled properly by those in lower executive positions. The exclusion of such cases can be obtained by having the executives determine *zones* on the charts, it being understood that as long as the points fall within the zone he is not to see the charts unless he specially requests to see them. He is, however, to have sent to him, for initialing, any chart having a point that falls outside his excluded zone.

An executive of any class will find it beneficial to see exceptionally large cases of deviation on the desired side of the line so that he can recognize and appreciate and take a personal interest in cases of unusual efficiency. It is through such cases that he gets in touch with unusually good methods. This is a check on the exception principle of the time-study-man's work. It also gives the executive valuable opportunities on the exception principle for proper managerial decisions in cases of the selection of candidates for promotion under the "three-position plan" of promotion and organization building. The curves showing progressive averages of departments may be examined at times farther and farther apart, these intervals to be determined in each particular case by the favorable or unfavorable comparison of records of such averages showing outputs and costs, with the prophesied outputs and costs. The executive is thus relieved later of work which is necessary at first, but which is not necessary when the particular case is running satisfactorily.

It is impossible to prophesy with accuracy what the amounts of outputs and costs should be without motion study and time study. But once these have been made and the actual outputs and actual costs approximate those prophesied, the high executives should devote very little time indeed to inspecting this class of charts. Instead, they should spend their time on other work, other departments, and more important things where their supervision will bring more valuable results.

It will be seen that these "Output, Cost and Causes Charts," with the "exclusion zones," enable the executive to eliminate the motions required for general oversight and inspection until a place on a chart is brought automatically to his attention where he can actually help those below him and furnish them with better instructions for handling their work more efficiently; or for making such changes as will naturally result in promotion, or the selection or shifting of individuals better fitted to do work elsewhere. The possibilities of relieving the executive of unnecessary motions and of enabling him to be more efficient in his own work are not exceeded in the case of any manual worker.

THE PENCIL ELECTRODE METHOD OF WELDING FOR BOILER JOINTS

By E. A. WILDT, SCRANTON, PA.[1]

THIS paper has special reference to the welding of joints of drums and not boiler shells as the latter term is commonly understood. The trend of the times is towards that type of boiler in which all the tubes are bent, particularly in the large units such as those at the Commonwealth Edison Station in Chicago, the Delray Station in Detroit, the Ford Automobile Factory and the Solvay Process Company. Since the dimensions of the boiler rooms are growing out of all proportion to the size of the engine rooms, and every item making for a decrease in the size of parts so as to reduce the room for the boilers is in demand, much higher pressures will be resorted to—an item for making the reductions required. Drums are to be used up to 60 in. in diameter, and in order to bear a pressure of 300 lb. or 500 lb. the thickness of the plate will be very close to 2½ inches.

With regard to making the joints in such a drum, is it not more feasible to weld them instead of employing the usual butt strap? There are several methods of making this joint by spot welding, and that which seems to have forged its way to the front is the pencil form of electric welding, which is now fairly generally used in steam-boiler work, although as yet recognized only for low pressures. The weld made by this process is not so hard as others of the autogenous kind.

In a weld, two pieces of metal heated to the proper temperature are united into one solid piece. Success of the process depends on bringing the pieces of metal to the proper heat. For this purpose we have the oxy-acetylene torch, the thermit process and the electric arc, the last of which is the form of modern welding particularly referred to here.

Electricity is used only to supply the heat, and in the pencil method only just enough heat is obtained to accomplish the joining of the two metals. No reference is here made to any particular design or set of apparatus: some are built to use a uniform voltage, others to use uniform amperage or uniform wattage. All autogenous welding is accomplished by adding new metal to the joint to be made, and it is only in the pencil electric arc method that positive incorporation of the added metal with the metal to be joined is secured. The opposite was the case in some recent failures in other forms of electric and gaseous welding wherein fluidity of both the added metal and the pieces to be joined is a necessary condition. By the electric pencil method fluidity is avoided and only just enough heat is used to make the plate and the electrode plastic, and there appears also to be an action in it which in the direction of the current tends to pull the metal from the electrode to and into the plate when just at the proper heat. This is so much in evidence that welding can be carried on overhead without the metal dropping upon the operator.

The temperature in the added metal in the gaseous and electric carbon type wherein fluidity is a condition approaches 2800 to 3000 deg. fahr., while in the electric pencil method the temperature in the metal being added is not more than 1500 deg. fahr. As a result the added and the adjacent metal in the weld is not rendered so hard as would otherwise be the result. This is also proved by the fact that, while cutting can be done with other methods, no cutting can be done with the metal electrode.

This point that the temperature of the arc is so high, so hot, that there is danger of the metal becoming vaporized, is answered by the fact that the conditions surrounding this particular form of spot welding are analogous to and the same as for "forge welding" as carried on by the everyday blacksmith at his anvil; there he has a fire very much hotter than the pieces to be welded are required to be heated to; in fact, it must be so; there must be a considerable surplus of heat for quick action; the blacksmith watches and if through carelessness the pieces are overheated, he says they are burned and spoiled and has to begin over again.

No other form of welding has the characteristic this one has, wherein there is an automatic action which prevents overheating, actually showing that in this regard it is equal if not superior to "forge welding."

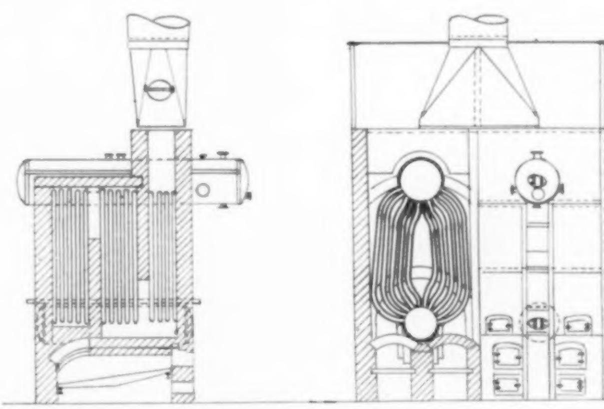


Fig. 1 Battery of two 100-hp. Water-tube Steam Boilers. The Welded Head Joints are Visible Outside the Brick Setting

The form of welding approved in the A.S.M.E. Boiler Code, known as Forge Welding, entails in its operation the production of big expansion strains, because the whole seam and the seam only is made at a welding temperature, producing an upsetting of the plastic metal by the unexpanded portion of the adjacent metal, so that when the forged welded seam has cooled off, the adjacent unexpanded metal produces tensile strains of very considerable strength, tending to pull the welded portions apart as it contracts, to the extent of close to ⅛ in. per ft. of the seam. In comparison with this, the metal electrode pencil method is a great improvement, because due to the very small area of metal heated the expansion strains are but fractional and may be considered negligible. Both the approved forged welding and this method of welding which is hereby submitted to the Boiler Code Committee for approval are exactly alike in the particular that the metal is not heated in either beyond the point just necessary to produce welding; when it comes to expansion strains they are less in the latter, and in both methods the weld improves with age.

[1] Lackawanna Boiler and Grate Company.

Abstract of paper presented at the Steam Boiler Session of the Annual Meeting, December 1916, of The American Society of Mechanical Engineers.

Although the electric heat reaches an estimated temperature of 6500 to 7000 deg. fahr., in this process the metal wire does not have time to reach this temperature before it is added to the plate or in the usual groove which is to be filled with the welding metal. As fast as the metal wire becomes just plastic, the pencil must be advanced towards the work, or the arc gap will become too long for the electric arc to maintain its circuit. The distance needed for the arc does not amount to much more than 1/16 in., because the voltages used are low, rarely exceeding 60 or 70, and failure on the part of the attendant to maintain this distance by constantly advancing the pencil is met at once by the extinguishing of the arc, because the gap becomes too long for it to maintain itself.

Only in this process, carelessness is practically eliminated, both as to overheating and heating any considerable area, and the heated area is confined to the smallest dimensions

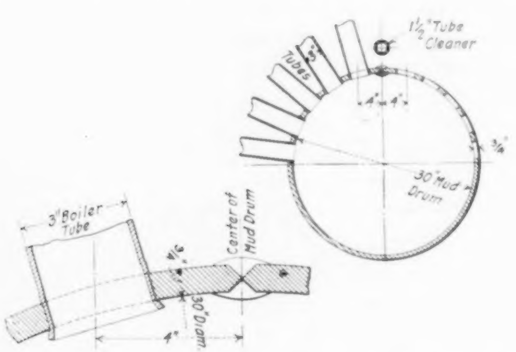


FIG. 2 CROSS-SECTION OF MUD DRUM, SHOWING ELECTRIC WELD WHICH IS NOT IN CONTACT WITH FIRE

of any; therefore the expansion and contraction strains are smallest. The wire forming the electrode only gets red hot at the point, showing the very localized character of the heat, the balance of the wire remaining black; while in the carbon form of electric welding, the carbon gets very hot from the point up to the holder.

Tests have shown that for pressures of 500 lb. per sq. in., and with plates of 2½ in. or similar thicknesses, this method of welding makes a better joint than straps and rivets. The maker of such joints can always know by the hydraulic test whether his work is done perfectly or not. Test after test shows there are no leaks; all you have to do to insure a perfect job is to secure an operator willing to do a good job, pay him well, and it is fair to say that it is then practically impossible to do a defective weld by this method.

In electric carbon arc welding of rolled stock, the metal in the weld cannot have the same properties as that in the original piece; it may have the same tensile strength but it will not have the same elasticity. This is a limitation in *any* welding process, but in this particular process the metal in the weld is changed the least of any, and in fact shows a tendency towards a fibrous condition. The metal of the weld can be controlled by the kind of metal that is added; low carbon steel will make the weld more ductile, high carbon steel will make it higher in tensile strength. A test piece made up entirely of the welding wire showed an elongation of 16 per cent.

In order to be sure that a joint so made will be stronger than the plate, and last indefinitely, it is only necessary to keep on adding new metal until the cross-section on both sides amounts to more than the plate itself. This can be carried to extremes, and may as well be, just filling the groove, usually V-shaped, the extra metal to lap over on each side ⅜ or ½ in., and made in bulged form, both inside and outside of the drum, taking on the form somewhat of a butt strap joint.

There has just recently been put into service, with a view of trying it out in actual practice, a small water tube steam boiler (Figs. 1 and 2) of the vertical 2-drum type, with all the tubes bent tubes, the drums in which have not a rivet in them. Heavy tests have been applied, and there is not the slightest doubt that the men who have to do with the erection of this boiler do not anticipate any danger to anyone from it. Of course, it is realized that the construction has not been approved, but it is necessary for someone to take a stand and bring it to a head. Without something to show and to test, there will be no basis on which to ask for an approval. The situation is somewhat analogous to the man who wants to obtain a job as a stationary engineer,—not having a license he cannot obtain the job and not having the job he cannot obtain the license.

DISCUSSION

JOHN C. MCCABE. I would like to ask Mr. Wildt as to the temperature of 1500 deg. fahr., which seems to me rather low. I would like to ask also how he eliminates the possible stresses set up internally in the weld. As I understand the problem, if he has a differential for each degree difference in temperature between the different plates, there is an internal stress of about 195 lb. The other point is, you can determine the safety of a vessel by the electrostatic test. It is well known that electrostatic pressures are seldom allowed anywhere near the elastic limits of the metal, and in the tests and investigations of failures made, I have found the welding material varied, the per cent of elongation running from a fraction of one up to 11, and in view of the bendings or flexures that occurred in the best-formed cylinders, I fail to see how an autogenous vessel, as we understand the problem now, can be considered a safe one.

CHRISTOPHER H. BIERBAUM. Is not the great difficulty with all autogenous welding for boiler plates the fact that so much of the plate adjacent to the weld is heated, the elastic limit of the plate reduced, and its elongation increased? The test pieces which have been exhibited here show that very fact. There is no break in the weld. We know that autogenous welds can be made as strong and stronger than the original metal, and especially in the case where the weld is left a little thicker than the body of the metal itself. But do not the internal strains set up and the heating of the plate adjacent to the weld decrease the elastic limit of the metal in the neighborhood of the weld, and induce conditions which should be very carefully determined before any theoretical conclusion can be drawn?

P. A. E. ARMSTRONG.[1] I do not think the forge process of welding is the only process valuable for boiler work; it is not as reliable as could be desired because of the difficulties of thermal disturbance in the metal in the vicinity of the weld. Thermal disturbance is brought about by two things, time and heat. In the vicinity of the weld the grain of the steel is enlarged and the tensile strength of the metal has fallen about one-third. I have conducted over a thousand tests on welds

[1] North American Company, 30 Broad St., New York.

in Sheffield, England, in working up a high-class steel suitable for welding, and found that with ordinary 0.30 to 0.40 carbon steel it was impossible to get more than about 60 per cent of the original strength, yet the breaks did not occur in the weld but some two or three inches away from the hammered area. In every instance the break occurred because of an enlarged grain.

The crystal grain of the metal, providing the thermal disturbance has not reached the point of incipient fusion, can be recovered by subsequent heat treatment, but this is hardly applicable for boiler work; I think it is absurd to talk of annealing the shell of a boiler 30 ft. in length. When annealed, this shell would expand and buckle in all directions. If this boiler had riveted joints, the expansion and contraction would be so great that a movement would be set up at the riveted joint, and no amount of calking would give a tight joint; in all probability it would augment the looseness of the rivets.

The oxy-acetylene or gas process generally is a very good one, but the thermal disturbance in the metal outside the weld is very similar to that present during forge welding. The electric carbon arc welding is worse. The electric bare wire welding, known as the metallic pencil welding, overcomes thermal disturbance to a greater degree, but the deposited metal in the weld is distinctly cold-short. This cold-shortness could be improved by annealing, but this is quite impossible under boiler conditions. By duplicating steel bath conditions, however, we obtain a fusion process, where the fused metal has a structure which is practically as good as the original steel.

If you take a bare wire electrode and coat it with a large quantity of slag, it is possible to melt this electrode so that the fusion takes place under the slag and the deposited metal would have all the characteristics of ingot steel of a given carbon content. Such an electrode has been developed and is extremely suitable for the welding of boilers and pressure tanks generally. The exterior slag coating of this electrode has the effect of localizing the heat. The metallic core is fused so rapidly that there is practically no thermal disturbance in the vicinity of the weld and complete fusion takes place.

Fig. 3 shows a bare wire electrode. A globule of metal is just leaving the end of the electrode, to be passed across the arc and deposited upon the metal to be welded. The flame or highly incandescent gases immediately underneath the electrode are very nearly neutral; at the outside of the arc flame the burning gases are extremely oxidizing. It is here that the damage takes place. A very interesting experiment can be conducted to prove it. If a bare wire electrode is fused, a crater is formed immediately beneath the fusing end of the electrode. If the circuit is broken and the arc extinguished, then at the bottom of the crater there is a complete absence of oxide of iron, whereas on the top edge of the crater and right over the deposit a layer of about 0.01 in. of oxide of iron is present, which proves that in the center of the metallic arc there is a neutral place. If the flame is examined spectroscopically, its oxidizing nature can be very quickly traced, and the neutral zone can be discerned in the center of the flame when the outside of the arc flame is slightly disturbed.

The slag electrode in operation is shown in Fig. 4. The end of the electrode is in actual contact; in the bare wire case there is a space of about 1/8 in. between the fusing end of the electrode and the work. There is a complete absence of the arc flame effect, and the incandescent slag is passing off from the end of the electrode on to the work. The atmosphere of the slag electrode is practically neutral as the vapor is composed of vaporized slag and not of highly incandescent gases. The voltage across the arc is higher than that of the bare wire system, because the vapor offers a greater resistance to the path of the current, although the arc is shorter and should take only about half the volts to get across, if both arcs were atmospheric.

Fig. 5, 90 magnifications, shows manganese steel of 12 per cent deposited upon manganese steel of a like content. There is no thermal disturbance. The diffusion between the original and the added metal is very complete, showing an entire absence of oxide. The cementite occurring in the globule formation and very evenly distributed over the mass shows absence in the deposited metal of austenic needles.

FIG. 3 BARE WIRE ELECTRODE

FIG. 4 SLAG ELECTRODE

Fig. 6, 90 magnifications, shows 0.125 carbon deposited upon 0.65 carbon. There is complete diffusion, and the carbon of the original steel is saturating into the lower carbon of the added metal. There is a complete absence of thermal disturbance immediately adjacent to the weld; the grains of pearlite and ferrite are the same size at the area of diffusion as they are half an inch under the weld, the time factor playing a very important part. I have seen a piece of low-carbon steel which has been for about six months at 600 deg. cent., the ferrite grain of which when etched was 1/2 in. across. This metal was absolutely cold-short, had practically no ductility and was extremely low in tensile strength. After submitting to two heat treatments the grain of the metal was practically normalized.

As it is impossible, in a general way, to anneal welds in boiler construction and so normalize the grain, it is essential that the time factor be reduced as much as possible. This illustration proves it. The heat was at least 6000 degrees, the time something less than a second; hence the grains did not have the time to change and assume the size and formation of the superheated temperature. The metal in the vicinity of the weld is quite as strong as it was before welding, and the added metal will have all the characteristics of ingot steel, in this instance 0.125 carbon. The structure of the added metal is given in Fig. 7, 250 magnifications. It is taken about half an inch above the line of diffusion. The grain is of small size and excellent structure, the pearlite and ferrite grains being very consistently arranged, and there is a complete absence of enlarged grains due to subsequent thermal disturbance.

Table 1 is taken from a Report of the Department of Commerce and Labor, Steamboat Inspection Service, dated January 27, 1916, on the tensile strength of four samples of slag welding for marine boilers submitted.

TABLE 1 TENSILE TESTS ON SLAG WELDED PLATES

Numbers on plates	1	2	3	4
Thickness of samples, decimals in.	0.494	0.494	0.743	0.521
Widths of samples, decimals in.	1.00	0.991	1.00	1.023
Strain at which each sample parted	28000	27500	42120	31890
Strain per sq. in. of section, lb.	56689	56530	56680	59840
Reduced thickness of sample	0.685	0.660	0.948	0.852
Reduced width of sample	0.282	0.300	0.725	0.419
Reduction of area, per cent	60^{o}%	59^{5}%	7^{o}%	33%
Length of straight part in center of test piece, in.	8	8	8	8
Elongation, percentage of	29^{o}%	25%	7%	14%

Sample No. 1 is the original steel of about 56,000 lb.; it broke at 56,680 lb. Sample No. 2 is a plate cut in half, welded and machine flush; this broke at 56,530 lb., $2\frac{1}{2}$ in. outside the weld, proving that the weld was stronger than the original metal and that there was no thermal disturbance in the vicinity of the weld. The elongation is 25 per cent, but this shows absolutely nothing, because the sample started to neck $2\frac{1}{2}$ in. away from the weld, and the reduced area resulting from this necking caused the fracture. Sample No. 3 is a plate cut in two, welded and reinforced $\frac{1}{4}$ in. down the entire length of one side. This sample broke in the weld and the tensile strength was 56,680 lb., identical with sample No. 1, which proves that the weld was of about 56,680 lb. tensile strength. The elongation was 7 per cent, and as the sample broke in the weld the necking occurred there, and it is quite reasonable to suppose that the elongation in the weld was somewhere near 7 per cent. Sample No. 4 was a plate reinforced on one side and then the welded metal entirely machined off, leaving the original plate at its original thickness. This plate was prepared so as to find out what effect the thermal disturbance had upon the metal adjacent to the weld.

As will be seen, the tensile strength of the metal has been increased and the ductility reduced. This is to be expected from the slight thermal disturbance taking place, as the added metal was as thick as the original steel. The results according to the test sheet show at least the great tensile strength of the welds made by this slag electrode.

Corrosion and welding are closely associated. It has been proved that corrosion is electrolytic in character, the positive pole of the small galvanic couples being highly corroded and the negative pole being practically free. When testing a piece of boiler steel for polarity, it is shown that there are numerous places where corrosion can be set up, due to electrolysis; all mechanical work on iron and steel will immediately start corrosion due to electrolysis, the electrolyte being supplied by the atmospheric moisture. A simple experiment will prove this. If a small portion of a piece of steel, neutral across its entire area, is hammered and tested for polarity, a voltaic circuit is present, the stress from the hammered portion being electro-positive and the original steel being

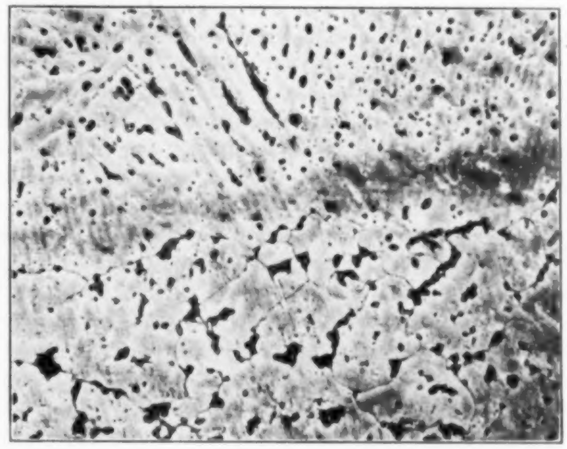


FIG. 5 12 PER CENT MANGANESE STEEL ON 12 PER CENT MANGANESE STEEL, MAGNIFICATION 90

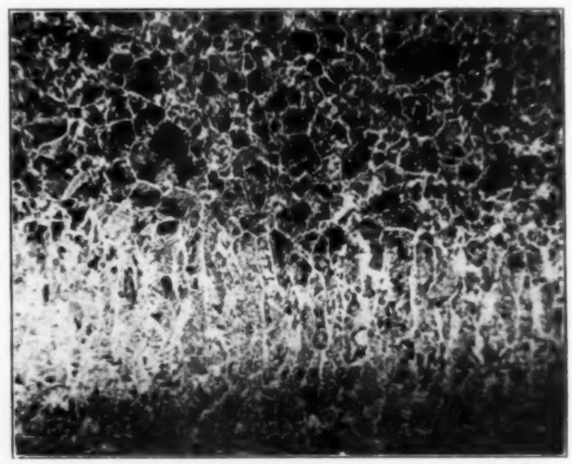


FIG. 6 0.125 CARBON STEEL ON 0.65 CARBON STEEL, MAGNIFICATION 90

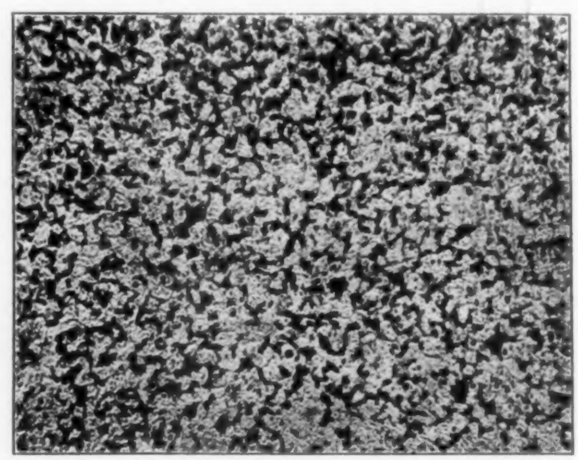


FIG. 7 STRUCTURE OF ADDED METAL, MAGNIFICATION 250

electro-negative; therefore it follows that every rivet head, calked edge or hammered portion of the boiler is electro-positive to its shell generally. Thermal disturbance and small mechanical work will set up polarity, and such a weld will be distinctly electro-positive to the surrounding metal. This is particularly noticeable in machine welded flue tubes in locomotives; 90 per cent of the corrosion taking place will always be present when the added length of tube has been made to recover short tubes. Autogenous welding is distinctly electro-positive to the surrounding metal, because the added metal is less pure, containing magnetic oxide of iron and other impurities. An oxy-acetylene or gas weld made on a pressure tank or boiler may be badly pitted by corrosion. A weld by carbon arc corrodes to a greater extent, and welds by the bare wire pencil method are certainly no better. Tests can be easily made by means of a millivoltmeter.

The deposit by the slag electrode is so pure that the added metal by this process is quite electro-negative to the surrounding metal and to a very large degree obviates corrosion at the weld. If the subject of corrosion is borne in mind, I am tempted to say that forged welding will not be permitted; some fusion process will be adopted wherein the corrosive influence of an electrolytic circuit is to a very large degree restricted.

VICTOR MAUCK. In all processes of welding it is necessary to raise the temperature of the metal to be welded to the point of fusion. Given a neutral flame free from non-combustible impurities, such as sulphur, nitrogen, etc., the arrest of the heating process at the exact point of fusion, and a uniform contact of the parts, a perfect weld of practically equivalent strength, section for section, to the adjacent metal would result. However, there are so many factors involved over which we have but indifferent control that this result is rarely attained. It is therefore necessary first, to rate the efficiency of the weld based on average manufacturing practice; second, to provide an ample factor of safety. A sufficiently high hydrostatic test pressure should be specified to insure ample minimum strength; and I lay particular stress on high test pressure.

In a riveted joint the fundamental operations are uniform and of a mechanical nature, affected but slightly by the human equation. The weld on the other hand has a much higher theoretical strength, but is *all* human equation, hence the importance of the high test pressure. A weld will vary widely in strength throughout its length, but this variation is less than in a riveted seam. Welds cannot be made commercially (except one form of electric weld) without more crystallization of the metal, and will lead to eventual failure under vibratory action if provision is not made for a sufficient factor of safety. It is possible to surround the processes with all reasonable precautions, in the public interest, and at the same time allow them that latitude for development they deserve, and which is conceded them abroad.

The process of electric welding by induction probably attains the nearest to the theoretical possibilities of any weld we have. The operation, being entirely mechanical, is uniform and under perfect control. There is no crystallization of the metals and the human equation is practically eliminated. The heat in this process is generated within the stock itself, radiating from the surface as opposed to the application of a very intense external heat, as in the oxy-acetylene flame or electric arc. In the latter case the surface is overheated before the body of the metal reaches welding temperature, with resultant burning and crystallization. In this process 100 per cent welds are the rule rather than the exception.

The production of pig iron in the United States last year amounted to 39,450,000 tons, according to *The Iron Age*, which is about 30 per cent in excess of the output for 1915. The production of steel in 1916 was probably in excess of 42,000,000 tons.

The Council of The Institution of Civil Engineers of Great Britain have extended an invitation to any members of The American Society of Mechanical Engineers who may be visitors in London to use The Institution Library and Reading Rooms, as well as to attend the meetings of The Institution, and have authorized the necessary steps to give effect to this on the presentation of an introduction from our Society. The Council trust that their American professional colleagues may often visit and make use of the new home of the Institution.

In the cooling of electrical machinery, with the high-speed units of large output, the designer is seriously handicapped. In a 15,000 kva. turbo-alternator, say, which is a medium size nowadays, the total loss is about 545 kw., and an enormous volume of cooling air is required for carrying away the heat due to this loss. According to Mr. B. G. Lamme, an expenditure of 1 kw. in 1 min. will raise the temperature of 100 cu. ft. of air 18 deg. cent. Therefore, for a temperature rise of the outgoing air of 20 deg. cent. above that of the incoming air a loss of 545 kw. will necessitate a supply of ventilating air of approximately 50,000 cu. ft. per min.—*The Electrician* (London), Feb. 2, 1917.

The endothermic energy of acetylene makes its ignition temperature low, thus preventing high compression in an engine cylinder. This in turn detracts from the efficiency of the engine and bars the economical use of this gas for power purposes. As compared with all other industrial substances acetylene occupies a position at the top of the list for light and heat. To get a substance which would compete with acetylene in its present field it would be necessary to get one with a higher endothermic energy content. Through well-known laws of chemistry it is recognized as impossible to obtain such a substance by any combination of carbon and hydrogen.—*The Engineer* (London), Feb. 23, 1917.

Mr. Max Toltz, member of the Council of the Am.Soc.M.E., recently introduced into the House of Representatives of the State of Minnesota a "bill for an act to provide for the safety of life and property in this state in the construction and use of steam boilers; creating a board of boiler rules to prescribe regulations for boilers used in this state, which will be uniform with other state rules now in existence, in order to provide for the free interchange of boilers between states; to define the power of the board of boiler rules; to provide penalties for the violation of this act and rules and regulations of the boiler rules."

The bill provides for the appointment of a board consisting of preferably a professor of mechanical engineering of the University of Minnesota, a manufacturer of boilers, a user of boilers, and a consulting engineer. The board is to formulate rules for the construction of steam boilers, as nearly as practicable in conformity with the A.S.M.E. Boiler Code.

JUNIOR AND STUDENT PRIZE PAPERS

On the recommendation of the Am.Soc.M.E. Prize Committees, the Junior Prize for 1916 was awarded to L. B. McMillan for his paper entitled the Heat Insulating Properties of Commercial Steam-Pipe Coverings. Honorable mention was awarded to Victor J. Azbe for his paper on Power Plant Efficiency, and Herbert B. Reynolds for his paper on the Flow of Air and Steam through Orifices.

Student Prizes for 1916 were awarded to: Boynton M. Green, Leland Stanford University, for his paper on Bearing Lubrication; Howard E. Stevens, Rensselaer Polytechnic Institute, for his paper on An Investigation of the Dynamic Pressure on Submerged Flat Plates, and M. Adam, Louisiana State University, for his paper on The Adaptability of the Internal-Combustion Engine to Sugar Factories and Estates.

Honorable Mention in the Student Prize Competition was awarded to: M. Boyd Gordon, University of Cincinnati, for his paper on A New Type of Uniflow Engine; S. C. Williams, Stevens Institute of Technology, for his paper on Photostatic Reproduction, and Charles P. Miller, Pennsylvania State College, for his paper on Investigation of Properties of Low- and Medium-Carbon Steels.

Abstracts of the papers awarded Junior Prizes have already appeared in The Journal and abstracts of the papers awarded Student Prizes are published below.

DYNAMIC PRESSURE OF SUBMERGED FLAT PLATES

By HOWARD E. STEVENS,[1] AUBURN, N. Y.

The object of this investigation was to find an equation expressing the relation between the velocity of a stream and the resulting pressure on a submerged flat plate held perpendicular and at right angles to the direction of flow. Experiments were conducted with the plate at different depths below the surface in order to establish whether this affects the equation. The effect of varying the area and shape of the plate was determined, and one plate was used only partially submerged to ascertain whether the same equation would hold.

In all these experiments the plate was moved through still water. Now, there might be some question as to whether such results would apply to moving water impinging on a stationary plate. In the early part of the nineteenth century Duchemin found that results obtained by one method apply to the other. Such authorities as Lanchester, Zahm and See all agree that the cases are identical. However, De Villamil says they would be the same only when surrounding conditions are identical. Thus, results obtained by moving a body in still water would only apply to a stationary plate if the moving water were in a static condition; that is, if tank and water were moved as a whole. In refutation of this statement, it is very evident that the water impinges on the plate just the same whether the tank moves or not, and is in no more static condition with reference to the plate than if it were an open stream.

The plate was fastened to a vertical piece of sheet steel, *F*, Fig. 1, which was bolted to a wooden block *A*. *F* was placed in such a position that, as the apparatus was moved, the thin edge cut the water. The upper end of *A* was forked, one arm going on either side of a framework *G*. At point *H* in each arm was a horizontal pivot, thus allowing *A* to swing to a vertical plane. Fastened to *A* was a horizontal arm of steel *J*. A link *K* with a horizontal knife edge across the bottom moved along *J*, and the knife edge rested in *V*-shaped grooves cut in the under side of *J*. To *K* was fastened a vertical wire *C*, the upper end of which was attached to the platform of a pair of scales. A small wire *D* fastened to the arm of the scales moved over a scale *E* as the arm moved up and down. This was to determine when the scales were balanced, as it was so arranged that then *D* was opposite the middle line of *E*. The frame *G* was clamped on a four-wheeled car which could be pushed along a track over a flume about 100 ft. long and 5 ft. wide. The axis of the frame was made parallel to the track, and the plate was made vertical with a spirit level (when the scales were in the balanced position), so that the plate was perpendicular to the direction of motion.

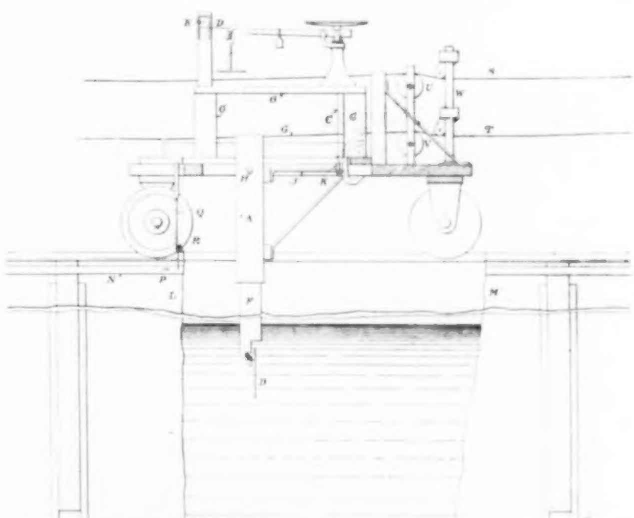


Fig. 1 Apparatus for Determination of Dynamic Pressure on Submerged Flat Plates

Fig. 1 shows a cross-section through the car and flume between points *L* and *M*, and an outside view to the left of *L* and to the right of *M*.

To determine the velocity a chronograph made by Wm. Gaertner and Co., of Chicago, was used. This had a revolving drum driven by clockwork to which a sheet of paper could be attached. Three pens which had a small lateral motion controlled by electromagnets made records on the paper as it moved. One pen recorded seconds. The electromagnet for this pen was connected in the circuit with a seconds pendulum on a clock. Every time the pendulum swung through its lowest point (once a second) a small needle on it passed through a bubble of mercury, closing the circuit. This excitation of the magnet pulled the pen sideways, giving little spines on the curve. A thin iron strip which ran along the side of the tank had little metal pins *P* every 8 ft., called "stations" in the following discussion. Attached to the car was an iron support *Q*, to which was fastened a flexible contact brush, *R*, which would rub on these pins. This would close the circuit through a second magnet and cause its pen to jump laterally. The third magnet was controlled by the experimenter, who

[1] Rensselaer Polytechnic Institute.

pushed the car. A horizontal handle was attached to the car with which to push it and on this handle was a push button. When the scales were balanced the experimenter closed the circuit through the third magnet by means of this push button, thus drawing the third pen sideways. In order to get a circuit while the car was moving, two trolley wires were used, S and T. Over these ran trolley wheels U and V, and other wheels on the standard W kept the wires pressed tightly against U and V, insuring a good contact. A wire connected U and V, and thus one circuit was made through W, P, R, Q, V, and T for the second magnet. The push button was connected by two wires to U and V, which thus gave a circuit for the third magnet.

Before making runs a plate was attached to F and the scales balanced to give the dead weight of the apparatus. Then weights were placed on the scales, the chronograph was started, and the car was pushed along at such a speed as to keep the scales balanced. Two runs were made with each weight. The weights used varied from 1 lb. to 40 lb., a sufficient range to give a good curve. One set of runs with various scale loads comprised a test. At the end of each test the plate was removed, a new dead weight found, and a series of runs made

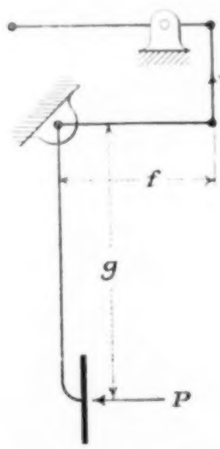


FIG. 2 FRAME DIAGRAM OF APPARATUS

in the same way with just the support of F to take the resistance of the water. These tests were called zero tests and gave the amount of pressure on the support. From these were plotted curves, scale readings vs. velocity. Log paper was used so that the curves would be straight lines and thus give a check.

First a 7-in. plate was used. The depth was varied by raising or lowering the level of the water in the flume. Then a round plate of one-half the area was used at three different depths. A rectangular plate 8 in. by 4 in. was tried with the long axis horizontal and then with it vertical, one test each way at a constant depth. A square plate 6 in. by 6 in. was next used at one depth only, and lastly the rectangular plate was used with the long axis vertical but only half submerged, giving virtually a square 4 in. by 4 in. below the surface. All the plates were painted. They were ⅛ in. thick.

Following is the method of computations. Three curves were obtained from the chronograph records: a, the seconds curve, the distance between two spines representing one second; b, the stations curve, each space between spines representing 8 ft. moved over by the car; c, the curve made by the pen controlled by the push button on the car. Where this is to the left, the scales were balanced, and only that part of the run (d to e) is of value for computations. The number of spaces on a between the spines nearest d and e was counted and the distance in inches measured. Dividing one by the other gave the seconds per inch of the curve. This was repeated with b, giving the stations per inch of the curve. Since each station represents 8 ft., multiplying the last result by 8 gave the feet per inch of curve b. Dividing this by the seconds per inch gave feet per second, or velocity. The weight on the scales was of course known and the dead weight was subtracted from it. Then the amount of pressure on the support at the known velocity was found. The difference between them gave the net weight on the scales corresponding to the pressure on the plate only. By knowing the lever arms f and g, P, Fig. 2, was computed; $Pg = fW$.

De Villamil says the desired equation is parabolic in form, therefore one was assumed:

$$P = KAV^n \qquad [1]$$

where P = total pressure on the plate in lb.
K = a coefficient
A = the area of the plate in square feet
V = the velocity in feet per second
n = a constant.

Dividing [1] by A, $P/A = KV^n$; passing to logs, $\log P/A = \log K + n \log V$, which is a straight-line formula.

P/A was computed for each run and $\log P/A$ was plotted as a function of $\log V$. Naturally these are straight lines; n is the tangent of the angle between a curve and the horizontal axis, while $\log K$ is the intercept on the vertical axis; n was found to be 2, while K had various values.

Then K was assumed to depend on the depth and the relation was taken as

$$K = b\ D^m \qquad [2]$$

where b = a coefficient
D = depth of center of plate below surface in feet
m = a constant.

Then $\log K = \log b + m \log D$, which is a straight line.

Log K was plotted vs. $\log D$ for each series (a series was composed of all the tests on one plate); m is the tangent of the angle between a curve and the horizontal axis and $\log b$ is the intercept on the vertical axis; m was found $= -0.1$, while b had various values. This in [2] gave $K = b/D^{0.1}$.

Then b was assumed to vary with the area. Two equations were assumed, $b = cA + g$, and $b = dA^f$. Several runs throughout the experiments were computed each way and the majority lay nearer the former curve than the latter, hence this was chosen; c was found to be 0.6, while g varied from 1.20 to 1.29, according to the shape of the piece. Since these are so nearly alike, it may be said that the shape of the plate is immaterial, and the average value of $g = 1.25$ will be taken.

Now [1] is $P = K\ A\ V^2 \qquad [3]$

Substituting for K its value,

$$P = A\ V^2\ b/D^{0.1} \qquad [4]$$

Substituting for b its value,

$$P = A\ V^2/D^{0.1}(0.6A + 1.25) \qquad [5]$$

which is the desired equation between the pressure and the velocity.

The investigation was carried a little further. Since P/A is the pressure in lb. per sq. ft., $1/W \times P/A$ (where W = weight of 1 cu. ft. of water) will be the pressure head h_p.

Since V is the velocity, $V^2/2g$ = the velocity head h_v. Now, from [1]

$$\frac{P}{A} = K V^2$$

$$\text{then } \frac{P}{A} \times \frac{1}{W} = \frac{K V^2}{W} \times \frac{2g}{2g} = \frac{K \times 2g}{W} \times \frac{V^2}{2g}$$

$$h_p = \frac{K \times 2g}{W} \times h_v = K \times \frac{64.3}{62.4} \times h_v,$$

$$\frac{h_p}{h_v} = 1.03\, K.$$

Substituting the values of K found, this ratio varies from 1.31 to 1.67, with the average value of 1.47. Merriman says in his "Hydraulics" that it varies from 1.25 to 1.75, with best values from 1.4 to 1.5.

BEARING LUBRICATION

INFLUENCE OF SURFACE VELOCITY ON MEAN FILM THICKNESS

By BOYNTON M. GREEN,[1] PITTSBURGH, PA.

ASSUMING that a machine will do the work for which it is designed, its economic value depends on the degree of efficiency with which it will do that work. The energy supplied to it is consumed in three ways: in overcoming the external load, or in doing the actual work required of the machine; in deforming the various parts of the machine, and in overcoming friction. The energy consumed in doing the actual work required is a legitimate expenditure for which there is value received. If the machine is properly designed, the energy lost in deforming its parts is returned somewhere during the work cycle, because the parts will never have been stressed beyond their elastic limit and hence, on returning to their original shape, will liberate the energy spent in deforming them, while that spent in accelerating masses will be given back upon their return to their original velocities. This leaves the energy lost in friction, which is a direct waste. Some friction is inevitable, so the question is: how may this loss be reduced to a minimum?

HISTORICAL DEVELOPMENT

It is interesting to note that this important problem of design was the last one to be attacked from a scientific standpoint. For years after the designer was able to calculate with a fair degree of accuracy the stresses in frames, shafts, levers and gears, he was content to design his bearings by guess and precedent. This tendency to slight bearing design was fostered by low machine speeds and lack of efficiency data. But with the introduction of electricity as a motive power and the resulting higher speeds and ever-increasing demand for greater efficiency, the necessity for better bearing design became urgent.

The first important attempt to investigate the conditions obtaining in a bearing was made in 1883 by Beauchamp Tower, an Englishman, at the request of the Institution of Mechanical Engineers. He used a journal 4 in. in diameter by 6 in. long, the bearing only covering the upper half of the journal. He was able first to explain the difference between partial or greasy lubrication and complete or flooded lubrication. Tower's results were qualitative rather than quantitative, but they brought out the facts that there was probably a complete film of oil separating journal and bearing in the case of flooded lubrication, and that the conditions of bearing friction in the case of flooded lubrication approximate fluid friction more nearly than solid friction.

The next step was made in 1885 by Prof. Osborne Reynolds, who used Tower's numerical data as the basis of a mathematical discussion of the subject. Reynolds applied a hydrodynamic theory to Tower's data and obtained an equation between the variation of pressure over the surface and journal velocity, which explained the existence of the oil film at a high pressure. He showed the presence of a wedging action of the lubricant, and this in turn brought out the importance of the bearing allowance, or difference in diameters of journal and bearing. From this followed the discovery of the general law for pressure distribution throughout the oil film, and the fact that the point of nearest approach of journal and bearing changes position with change of load. Reynolds realized that viscosity changes with temperature, so he made a determination of the relation between viscosity and temperature for olive oil, and deduced an empirical formula from which he obtained expressions for the approximate variation of viscosity with speed and load, since both these affect the bearing temperature. These expressions brought Tower's results into very close agreement with Reynolds' hydrodynamic theory. The hydrodynamic theory of fluid friction was also developed independently in 1884 by Petroff, a Russian, (data published in German in 1887).

This theory is undoubtedly the correct one to apply to the case of flooded lubrication. However, it cannot be applied directly, as the equations contain several constants which can only be determined by experiment, and it is to this work that later investigators have turned their attention rather than to the development of new theories. In 1903 some important investigations were carried on by O. Lasche for the Allgemeine Electricitäts-Gesellschaft of Berlin. Up to that time investigations had only been made with loads under 500 lb. per sq. in. and velocities under 500 r.p.m. (among the most important were those by Stribeck, Z.d.V.d.I, 1902), and the A.E.G. found it necessary to obtain data for velocities up to 3000 r.p.m. and correspondingly high loads. Lasche's work was quite exhaustive and incidentally threw considerable light on the transmission of heat away from the oil film.

FLUID FRICTION

The general equation for fluid friction is

$$\mu = \eta V/py$$

where μ = coefficient of friction
η = coefficient of viscosity
V = journal surface speed
p = pressure per unit of projected area of bearing
y = mean film thickness.

Usually p and V can be determined from the conditions of the problem and values of η can be taken from known data on oils. Concerning values of y, nothing definite is known, but some general deductions can be made. According to Smith and Marx's Machine Design, 1915, it is a function of the running-fit allowance, of p, of V, and of the temperature t of the bearing, which may be summed up in the following expression

$$y \frac{k_a V^x}{p^w t^z}$$

From a consideration of this expression and its application in the general equation for friction it would seem that the

[1] Leland Stanford University.

next step would be an investigation of the mean thickness of oil film. Some work was done on this subject in 1897 by Professor Kingsbury (Jour. Am. Soc. Nav. Eng.), but as he used air as a lubricant, his results can only be taken as an indication of what to expect when using oil. As the mean film thickness y is influenced by four variables, it would be necessary to make the investigation in four steps. In Kingsbury's experiment the velocity only was changed. The pressure and allowance were kept constant while the apparatus was allowed to run until the temperature became constant before any test readings were taken.

EXPERIMENTAL PART

In the present experiment it was thought best to follow Kingsbury's lead and investigate the influence of velocity on mean film thickness, and the apparatus was designed with this point in view. The bearing is shown in section in Fig. 1; it is non-adjustable and consists of a plain phosphor-bronze sleeve about $3\frac{1}{4}$ in. in diameter by 7 in. long, pressed into a cast-iron housing which was bolted to a lathe bed. Lubrication was effected by two steel oil rings of rectangular section. Two sets of oil grooves were cut in the upper half of the bronze as shown in the figure. On assembling the bronze sleeve and housing, it was found that the bronze was elliptical in section, with the major axis vertical, the average difference in diameters being 0.001 in. To obtain the best results from the apparatus, the sleeve should have been reamed after pressing it into the housing. Although this was not done, the inaccuracy did not seem to affect the results appreciably.

The journal was a piece of mild steel, ground carefully to a diameter of 3.244 in., giving a running-fit allowance of 0.0035 in., or about 0.001 in. per inch of diameter. On each end of the journal was fitted a cast-iron flywheel weighing about 67 lb., secured by a nut. The total weight of the assembled journal, flywheels and nuts was 165.5 lb., making a nominal load on the bearing of 7.275 lb. per sq. in. of projected area. The whole apparatus was mounted on two parallel lathe beds, and three lathe heads with four-step pulleys were utilized for the drive. The usual overhead countershaft drove the first lathe head, which drove the second head by a short piece of shaft and dogs. The second head drove the third by a short belt and tightener pulley. It was found necessary after several preliminary trials to introduce the tightener, so that the second belt could be used for gradual acceleration of the heavy rotating mass. The third head drove the test journal by a piece of $\frac{1}{4}$-in. steel shaft about 2 ft. long. As this flexible drive rod was loosely connected by a dog to the lathe head and by a cotter pin to the journal, it is fairly certain that no external deflecting load was applied to the latter. With the drive arranged in this way, sixteen speeds were possible, but as all the cone pulleys were of the same design, some of the speeds were duplicated, so that only six speeds could be used.

With this apparatus it would be possible to vary the bore allowance by starting with a very small allowance and then grinding down the journal to give larger allowances. This procedure was contemplated when the apparatus was designed, but lack of time prevented tests with more than one allowance. To locate the position of the journal with relation to the bearing, three micrometers of a design similar to Kingsbury's were used. The micrometers and journal were placed in the primary circuit of an induction coil with a battery, and a telephone receiver was connected to the secondary of the coil. With Kingsbury's apparatus it was only necessary to mount one micrometer in the bearing, because his bearing was a simple cast-iron cylinder, so supported that it could be rotated about its own axis, thus bringing the micrometer into any position desired. His method was to locate the point of nearest approach and read the micrometer, calling this the zero reading. Then the bearing was rotated 180 deg. and another reading was taken. Half the difference between the zero reading and the second reading gave the radial distance between the axis of the bearing and the axis of the journal, and the angular displacement was read from graduations on the end of the bearing cylinder.

In the present experiment the bearing could not be rotated, so it was necessary to use three micrometers spaced 120 deg.

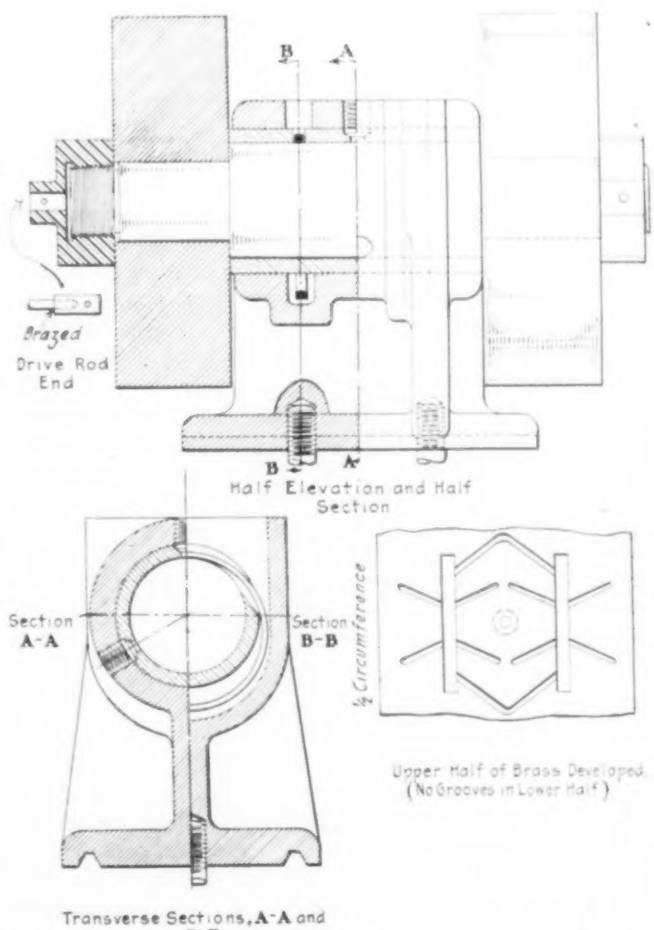


Fig. 1 Test Bearing

apart around the bearing in a plane through its center and perpendicular to its axis. The moving part of the micrometer consisted of a $\frac{1}{8}$-in. steel rod hardened at the contact end and threaded 40 threads per in. at the other end. To the threaded end was clamped a pointer $3\frac{1}{4}$ in. long which served both to turn the rod and to indicate the reading. The rod was carried in a brass sleeve threaded to receive it and electrically insulated from the bearing by a fiber bushing pressed on to the sleeve. The graduated scale was carried on an arm clamped to the top of the brass sleeve. This arm also carried a binding post for the electrical connection. The whole micrometer was held in place in the bearing by means of a brass collar which screwed down over the tapered fiber bushing.

The micrometers were calibrated by screwing them into a ring and then screwing down the micrometer point to touch a standard inside micrometer. The experimental micrometers were graduated in this way to thousandths and the ten-thousandth divisions were laid off from these major divisions. Micrometers 1 and 3 were graduated for a total of three thousandths, and micrometer 2 was graduated over a range of six thousandths. Before any test readings could be taken, it was necessary to set the micrometers to zero, i. e., bring the micrometer points flush with the inside surface of the bearing brass by placing inside the bearing a sector cut from a polished iron ring which had been ground to the exact diameter of the bearing. The zero readings of all the micrometers were checked after every three or four test readings.

The runs were made short purposely, usually under two minutes, to eliminate the temperature factor as far as possible. A long run was made at a constant speed to obtain some information concerning the influence of temperature on the position of the journal relative to the bearing, but the micrometer readings showed that the bearing itself was expanding very rapidly due to its thin section, so this investigation had to be abandoned. From ten to fifteen readings of each of the micrometers were taken at each speed and the most consistent of the readings at each speed were averaged to obtain the final experimental data which are given in Table 1.

In determining the mean thickness of oil film from the results the following approximations were made: (*a*) that the loaded portion of the film was that below a horizontal plane through the center of the bearing, (*b*) that the thickness of the film at this plane and on each side of the journal was equal to the radial bearing allowance, (*c*) that the mean thickness of film was the average of the thickness at this plane and the minimum thickness of the film. The minimum thickness of film is the radial allowance minus the distance between the axes of the journal and bearing. Making use of these approximations the resulting values of mean thickness of film are given in Table 2.

The general equation of the curve plotted is

$$y = b + c^a \sqrt{V} \qquad [1]$$

where y = mean thickness of film in in.

b = one half the radial allowance

c = constant dependent on allowance and possibly on viscosity

a = constant dependent on viscosity and possibly on allowance

V = surface velocity of journal in ft. per min.

By translating the horizontal axis of the curve the constant b is eliminated and the equation becomes

$$y = c^a \sqrt{V} \qquad [2]$$

From the experimental curve the values of c and a were found to be

$$c = 0.0000049,\ a = 1.8$$

and the resulting empirical equation is

$$y = 0.0000049^{1.8} \sqrt{V} \qquad [3]$$

As to the application of the empirical equation in the general equation for bearing lubrication, it may be said that it may be used directly for conditions of the same allowance and a lubricant having the same viscosity. For other allowances and lubricants the change of c and a cannot be stated definitely. It can be said in general that c will change with some function of the allowance and a with some function of the viscosity. It is also possible that c may be affected by the viscosity and a by the allowance.

The oil used during the experiment was an ordinary mineral oil, known as Vacoline, manufactured by the Standard Oil Company. Its viscosity as given by the Engler viscosimeter was 11.0 at 20 deg. cent. and 2.95 at 50 deg. cent. compared with water at 20 deg. cent., which gave a specific viscosity of 38.9 at 20 deg. cent. and 8.7 at 50 deg. cent.

TABLE 1 DISTANCE BETWEEN AXES

Average Experimental Data					Results	
V Ft. per Min.	Temp. deg. fahr.	Micrometer Readings, In.			Axial Dist. In.	Angle
		1	2	3		
0	..	0.0002	0.0035	0.0002	0.00175	90°00′
196	58	0.0001	0.0026	0.0006	0.00158	80°45′
306	66	0.0003	0.0025	0.0004	0.00153	88°10′
511	66	0.0003	0.0025	0.00065	0.00142	82°00′
817	78	0 0002	0.0023	0.0005	0.00134	83°00′
1224	70	0.00025	0.0021	0.0004	0.00125	86°05′
2042	80	0.0002	0.0020	0.0006	0.00113	77°40′

TABLE 2 MEAN THICKNESS OF OIL FILM

V	Distance between Axes	Min. Thickness Film	Mean Thickness Film
0	0.00175	0	0.000875
196	0.00158	0.00017	0.000960
306	0.00153	0.00022	0.000985
511	0.00142	0.00033	0.001040
817	0.00134	0.00041	0.001080
1224	0.00125	0.00050	0.001125
2042	0.00113	0 00062	0.001185

INTERNAL-COMBUSTION ENGINES FOR SUGAR FACTORIES AND ESTATES

BY M. ADAM,[1] PINA, CAMAGUEY, CUBA

THE internal-combustion engine is making such rapid progress that it will be of interest to consider its possibilities in the cane-sugar industry. Naturally, with steam engines the exhaust steam can be utilized for the various heating and evaporating operations. At times, however, there is absolutely no use for exhaust steam, and, as generally no bagasse fuel is then available, oil, wood, or coal would have to be used for the steam plant, depending on the locality. The use of an oil engine here would at first sight seem possible, but calculation shows that the saving realized would not justify the expense of a new installation. Another point of importance in Louisiana sugar factories is that when the temperature is low, the heavy oil will not flow by gravity, and several devices which have been tried are either costly or inefficient. The best solution would be to use a pump run by an internal-combustion engine.

But the greatest field for liquid-fuel engines is on the agricultural side of the industry. The labor problem on the average sugar plantation is a source of anxiety and trouble; the problem of feeding and caring for the draught cattle is also a serious one, though the use of mules and horses is imperative. The amount of animal power required is only 30 per cent at present in the production of the cane, including harvesting. Machines are, however, being developed to do the

[1] Louisiana State University.

harvesting, and it can be safely predicted that in a few years the horse will only be required to do about 8 to 10 per cent of the total.

The agricultural motor tractor, although it has many advantages, has not come in as fast as was expected. The first motor tractors were of very heavy construction, with the consequence that the soil was packed and the crop injured. Of late years, however, the light tractor has made its appearance, and is now no longer an experiment. Some of the best types are the Mogul, Wyles, Martin, Ivel-Bauche, and the Sanderson. The type to be used depends largely on the nature of the soil. In the caterpillar type of tractor the area of contact between the ground and the engine is very much increased, thus securing a greater drawbar efficiency and lower pressure per sq. in. on the ground. A caterpillar 24 in. wide and with 6-ft. length of contact gives the same pressure as a road wheel with a 120-ft. diameter and a width of 24 in. The pressure per sq. in. of a caterpillar is only about 4 to 8 lb., which is very much less than the pressure exerted by the hoof of a horse. A caterpillar will also travel easily on almost any kind of soil, a point of importance. The Martin's cultivator, with its light and simple construction, is of this type; it is made to use benzol or gasoline, as most of the tractors of English make. The Mogul type, however, can burn kerosene, which is so much cheaper than gasoline. Another possible application of heavy-oil engines in sugar plantations is for irrigation, and in some countries for drainage.

The heavy-oil engine has a decided advantage over other types also in fuel cost. The cost per b. hp-hr., excluding rent, administrative costs and electrical apparatus, works out from careful calculations, as follows:

Steam plant	1.605 cents
Gas-producer plant	1.222 cents
Heavy-oil-engine plant	0.813 cent

Gasoline plant was not included, as the cost would undoubtedly come even higher than that for steam plant, and it is safe to assume that an alcohol engine could not compete with the heavy-oil engine or the gas-producer plant. When we speak of heavy-oil engines, we have in mind the Diesel engine. This engine differs from all other internal-combustion engines in that a full charge of air is compressed to a point above the igniting point of the fuel and the fuel injected into it, when it burns under a pressure and temperature which can be perfectly controlled. There are no explosions, but a steady combustion at a predetermined lower temperature and without any increase in pressure, the combustion line being practically an isothermal. A small pump supplies the fuel to the chamber. A special compressor serves to compress the air to inject the fuel and to store a surplus in an air tank for starting the engine when cold. A very sensitive governor controls the quantity of fuel injected, regulating the heat, and hence also the expansive power of the air medium. Apart from high efficiency, a great advantage with this type of engine is that there is practically no limitations as to the kind of fuel to be used, so long as it is liquid.

In installing an irrigation plant for a large sugar plantation, the best arrangement would be to have a central plant near the sugar factory, delivering current at say 440 volts. This can be stepped up to 12,000 volts at the plant and distributed over the plantation, being stepped down again to 440 volts to each separate motor directly connected to its pump. It would be well to divide the power required between a steam plant and a Diesel plant. During grinding, most of the load would be taken by the steam generator, thus permitting the utilization of the exhaust steam. By partially electrifying, say, the centrifugals and machine shop, the summer curing of sugars and repair work could be done most efficiently, the load being then taken by the Diesel engines, as there will then be no use for exhaust.

To my knowledge there are no such plants in existence, though there are several using producer gas. The great Beira-Illovo estates in Portuguese East Africa are irrigated in this manner. Most of the property consists of flat alluvial soils; the water being pumped from the Buzi River by means of seven centrifugal pumps, three of which are operated by a suction plant. There is also another producer-gas irrigation plant in the tropics which is giving perfect satisfaction.[1] It consists of three gas producers and three gas engines directly connected to electric generators. There is also one water-tube boiler and a 800-hp. poppet-valve engine directly connected to a 600-kw. generator. Eleven pumps geared and belted to 50-cycle, 310-volt motors, furnishing water for the irrigation of the sugar cane, are located on the different haciendas. The gas plant consists of three double-acting, two-cylinder, four cycle, 18 x 24-in. Allis-Chalmers gas engines running at 200 r.p.m. The engines are supplied with gas by three R. D. Wood dry-bottom, updraft producers, which may be worked as suction or pressure, burning anthracite coal.

All the electric generators, directly connected to engines, are of 200 kw. capacity, and deliver 50-cycle current at 310 volts, which is stepped up to 15,000 volts at the power house. At the pumps the current is stepped down to 310 volts. The irrigating pumps are at a distance of ½ mile to 4 miles, respectively, from the power house; the main plant is located near the factory. The gas plant is operated all the year for irrigation and takes off the factory load on clean-up days and days when there is no demand for exhaust steam. Tests run on the gas-producer plant gave 1.742 lb. of coal per kw-hr. and 1.367 lb. of coal per b. hp-hr., which shows very high efficiency.

With a plant of this size, however, the Diesel engine would give more economical service, and the day will probably come when this type of engine will be universally used for such work as irrigation and drainage.

Since its use was brought to the notice of the world in 1809, the export of nitrate of soda from Chile has exceeded a total of 53,000,000 long tons, and the present output is in the neighborhood of 2,500,000 to 3,000,000 long tons per annum. It is safe to estimate that the known areas can provide nitrate of soda for another 200 years at the present rate of production.—*Metallurgical and Chemical Engineering*, Mar. 1, 1917.

It has often been said that the fixation of atmospheric nitrogen is not practicable in the United States because of the high cost of power. Now nitrate of soda costs $70 per ton in New York, which is equivalent to $95 per ton for pure nitric acid. In Norway and elsewhere it requires about 1.82 kw.-year to produce a ton of nitric acid. The Mississippi River Power Co. supplies power to St. Louis at $24 per kw.-year at 60 per cent load factor. At this rate the power necessary to produce a ton of acid would cost about $44, and the margin between this and $95 is sufficient to warrant a very careful inquiry before accepting the statement that "it cannot be done."—Charles W. Comstock, in *Proc. A.I.E.E.*, January, 1917.

[1] I am indebted to Prof. Kerr for this information.

WORK OF THE BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee as approved by the Council on March 16, 1917, in Cases No. 140 and 143. In this report, as previously, the names of inquirers have been omitted.

Case No. 140

Inquiry: Do small vertical tubular boilers built for operation in connection with laundry or clothes pressing machinery and which are less than 24 in. in diameter, necessarily come under the requirements of Par. 266?

Reply: The Committee has decided that all boilers 24 in. or less in diameter shall have at least one opening for inspection and one opening in addition to the blow-off for washing out the boiler, these openings to be fitted with brass plugs.

Case No. 143

Inquiry: Has any action been taken as yet by the Boiler Code Committee in the matter of eliminating the copper content requirement for firebox boiler plate steel in Par. 25? Great difficulty is now experienced in securing plate to meet the present requirements of this paragraph.

Reply: The copper content requirement has been eliminated.

The National Research Council has organized an investigation on the subject of Food Poisoning, to be undertaken by the Harvard Medical School in its department of preventive medicine and hygiene.

The American Association for the Advancement of Science and many national scientific societies affiliated with it will hold its 70th meeting in Pittsburgh from December 28, 1917 to January 2, 1918, under the auspices of the University of Pittsburgh, the Carnegie Institute, Carnegie Technical Schools and other scientific and educational institutions of the city.

As already published in The Journal, Congress appropriated last fall $35,000 to a monument in memory of John Ericsson, the eminent engineer, who was also a member of The American Society of Mechanical Engineers. This monument is to be erected in a prominent place in Washington. A special Commission was appointed by the Government, known as the John Ericsson Monument Commission, to take care of the details in connection with the erection of the monument. As mentioned in The Journal for March, 1917, six of the members of The Society are members of this Commission, which met at Chicago, March 10. It was the unanimous opinion that the sum appropriated by Congress would not be sufficient to erect a fitting memorial to a great engineer which would compare favorably with the memorials erected to men of other professions, and it was decided that at least $25,000 ought to be added to the appropriation made by the Government, in order that a fitting memorial might be erected. It is proposed to raise this amount by private subscription, and all American engineers, organizations, and societies are invited to aid in commemorating the memory of John Ericsson, who gave signal service to the country at a time when its very existence hung in the balance. It is the first time that the United States Government has made an appropriation for the erection of a monument to an engineer, and as this engineer was also a member of The American Society of Mechanical Engineers, it is hoped that the members of the Society will be proud in aiding the efforts of the John Ericsson Monument Commission. Subscriptions toward the monument will be received by Erik Oberg, Associate Editor of *Machinery*, 148 Lafayette St., New York, a member of The American Society of Mechanical Engineers, who is also a member of the Commission. Subscriptions thus received will be acknowledged by publication as directed by the Commission.

The Engineers' Society of Western Pennsylvania took steps at a recent meeting to create a suitable memorial to the late George Westinghouse, Past President and Hon.Mem.Am.Soc. M.E. The meeting bore testimony that he was a persistent and indefatigable worker upon problems involving the safety and comfort of mankind, and that as an inventor and engineer he was the most widely and favorably known man of his time.

The following resolution was passed unanimously: "Resolved, that this Society, through its President, appoint a committee of five members, to be known as the Westinghouse Memorial Committee, who shall investigate a plan for the purchase of the former home of Mr. Westinghouse, known as Solitude, consisting of ten acres of land, converting same into a public park, to be forever known as 'Westinghouse Park,' erecting thereon a suitable memorial, and turning the whole over to the city of Pittsburgh, under its guarantee that the gift shall receive the same care and protection as other parks owned by the city."

The committee appointed consists of George S. Davison, Julian Kennedy, Vice-Pres.Am.Soc.M.E., William L. Scaife, Charles F. Scott, Mem.Am.Soc.M.E., and E. B. Taylor.

Members of the Society will wish to associate themselves with their colleagues of the Pittsburgh fraternity in doing honor to a distinguished citizen and engineer, and an honorary member of the Society, and hope that their efforts will be rewarded by an early realization of the memorial proposed.

Society Affairs

Engineering Survey

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES

OFFICERS AND COUNCIL, 1917

President

Ira N. Hollis

Past-Presidents

Members of the Council for 1917

Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear
D. S. Jacobus

Vice-Presidents

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Terms expire December 1918

Charles H. Benjamin
Arthur M. Greene, Jr.
Charles T. Plunkett

Managers

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Terms expire December 1919

Robert H. Fernald
William B. Gregory
C. R. Weymouth

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

Ira N. Hollis, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
D. S. Jacobus
Charles T. Main
Spencer Miller

COMMITTEES, ETC.

STANDING COMMITTEE

Chairmen

Finance, Robert M. Dixon
Meetings, Robert H. Fernald
Publication, F. R. Low
Membership, L. R. Pomeroy
Library, John W. Lieb
House, Frederick A. Scheffler
Research, R. J. S. Pigott
Constitution and By-Laws, F. R. Hutton
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society Testing Materials, Joint Conference Committee
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National engineering Societies
Conservation
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial Association
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes
Am. Soc. M. E. Student Prizes
Boiler Code Committee, John A. Stevens
Conference Committee on American Engineering Standards
Conference Committee to Determine Cost of Electric Power, W. B. Jackson
Engineering Education
Flanges and Pipe Fittings
Increase of Membership, A. L. Williston
Joint Committee on Standards for Graphic Presentation, Willard C. Brinton.
Local Sections
Machine Tools Standardization
Metric System, L. D. Burlingame
National Museum
Nominating Committee
Patent Laws
Pipe Threads, International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee,
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Cutting Action of Machine Tools, Leon P. Alford
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Investigation of the Clinkering of Coal, Lionel S. Marks
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Materials of Electrical Engineering
- Sub-Committee on Safety Valves
- Sub-Committee on Steam, Flow Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park H. Dallis
Baltimore, C. C. Thomas, A. G. Christie
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, W. G. Starkweather
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit, M. E. Cooley, J. W. Parker
Erie, J. F. Wadsworth, M. E. Smith
Indianapolis, W. H. Insley, W. A. Hanley
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

[1]A complete list of the officers and committees of the Society will be found in the Year Book for 1917, and in the March, 1917, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

PRESIDENT HOLLIS is now on his second tour, covering this month the cities of Philadelphia, Pa., Schenectady, N. Y., Troy, N. Y., Buffalo, N. Y., Minneapolis, Minn., Indianapolis, Ind., Columbus, O., and Pittsburgh, Pa.

The message which Dr. Hollis is delivering to enthusiastic audiences was never more timely than now. The purport of it is that:

> We engineers can only take one attitude, that every citizen is permitted, even expected, to develop himself to the highest degree of service for his nation and mankind. There is only one way to do this, and it is for us to unite in the kind of good-will and good-fellowship that will enable us to work together towards the glory of our country—in peace, we hope, but in war if it is absolutely necessary.

The movement for this started throughout the world even before the present war, but of course the war has accentuated it both in this country and abroad.

The membership of the Society has recently received two circulars from the Engineering Societies' Joint Committee on Reserve Corps of Engineers; as a result about 1500 applications for commissions in the Engineer Officers' Reserve have been filed with the War Department. Perhaps one-third of these have been issued by the Secretary of War and signed by the President of the United States.

At the request of President Hollis, the presidents of the engineering societies have had two conferences with representatives of the National Council of Defense and of the Army and the Navy, with the result that there is in preparation a letter telling about the several departments of the service in which an engineer may enroll in the Officers' Reserve. In some of these departments the full complement has already been obtained, but in some others there is still a great need of reserve officers, particularly for members of this Society, experienced as they are in manufacture and in handling men.

Elsewhere in this issue is a resumé of the account of the opening and the dedication of the Science Building given by Past-President Swasey to Nankin University.

Letters have been received from both Dr. Brashear and Mr. Swasey telling of their wonderful trip to the Orient with Mr. Freeman and his two sons. The party is due to sail from Honolulu on the Tenyo Maru on March 27, reaching San Francisco April 2. Dr. Brashear states that when he boarded the boat at Vancouver 225 letters were awaiting him, and that in order to answer them all he has written ten articles for the Pittsburgh newspapers!

While on tour, Dr. Brashear gave two lectures in Peking, two at Shanghai, two at Canton, one at Manila and two on the ships on which he has been traveling. He has also promised our Committee on Meetings an address at the next annual meeting of the Society.

In one audience of his in Canton there were 1200 Chinamen and women, besides foreigners. In many cases his lectures had to be interpreted, interpreters being often Yale graduates to whom he kindly enough gave credit for delivering his lectures better than he himself did.

The party has met President Li Yuan-heng, the Vice-President, the President of the Senate and others of China's most brilliant men, both in politics, business and education. Mr. Freeman, in a conversation with the President of the Chinese Republic, emphasized the necessity for conservation in China particularly with respect to waterways.

Mr. Swasey is held in the highest esteem in China, where he has done wonderfully good work, both in the educational institutions and in the Y. M. C. A. During the trip, Mr. Swasey's seventieth anniversary was celebrated by a dinner given by Mr. Freeman.

The alumni of the Massachusetts Institute of Technology in Shanghai gave a dinner to Mr. Freeman and his sons also; in fact, the social entertainments were most complete wherever our friends visited.

This trip of our distinguished past-presidents calls to mind that we engineers, in our professional work and in our vacation trips, go all over the world. We thus have excellent opportunities for extending the greetings of the Society and developing the professional spirit universally. Please, therefore, invite engineers and officers of professional societies to call and send their friends to the Society headquarters, and we will do our best to assist them in whatever errand they may have.

CALVIN W. RICE,
Secretary.

Council Notes[1]

AT the meeting of the Council on February 16, the following members were present: Ira N. Hollis, *President*, presiding; John H. Barr, C. H. Benjamin, R. H. Fernald, W. B. Gregory, W. B. Jackson, D. S. Jacobus, Charles T. Main, Spencer Miller; Wm. H. Wiley, *Treasurer;* R. M. Dixon, *Chairman Finance Committee,* and Calvin W. Rice, *Secretary.*

Representation at Council Meetings. It was voted to add the chairman of the Sections Committee to those committee chairmen now receiving invitations to attend Council meetings and take part in the discussion of matters relating to their work. The chairmen of the Finance, Meetings and Publication Committees already receive such invitations.

Increase of Membership Committees. A. G. Kessler was appointed chairman of an Increase of Membership Committee for Erie and vicinity, and Charles T. Hutchinson of a similar Committee for San Francisco and vicinity.

A.S.M.E. Boiler Code. Interpretations Nos. 76, and 116 to 135 inclusive, of the Boiler Code Committee were approved as presented, with one exception, No. 125, which was slightly amended, and ordered published. They appear in the March issue of The Journal.

A request from the Compressed Air Society that the Boiler Code Committee consider the formulation of rules to cover pressure vessels other than steam was referred back with the

[1] The March Journal went to press before the February meeting.

request that the Society submit a brief covering the modifications of the Boiler Code it would recommend to meet the case.

Sections. Ernest Lee Jahncke was appointed on the executive committee of the New Orleans Section, in place of A. L. Black, resigned.

Student Branches were approved at Johns Hopkins University, University of Washington and University of Pittsburgh. The total number of Branches is now forty-three.

Engineering Standards Committee. In response to an invitation from the American Institute of Electrical Engineers for appointment of three representatives on a proposed joint conference committee of the national engineering societies, on a committee to bring about coöperation in American Engineering Standards, our Standing Committee on Standardization was authorized to appoint three of its members as the representatives of our Society on the joint committee.

Naval Consulting Board. Mr. Spencer Miller, one of the Society's two representatives on the Naval Consulting Board, reported the appointment of a Sub-committee on Special Problems, and that the Board is now holding frequent meetings, the proceedings of which are being kept confidential for obvious reasons.

Society Representation. Mr. Spencer Miller was appointed to represent the Society at the annual meeting of the American Institute of Mining Engineers.

Prof. H. E. Satterfield was appointed to represent the Society at the inauguration of Professor Ruddick as President of the North Carolina College of Agriculture and Mechanical Arts, on February 22.

Exchanges of Courtesies. It was voted to accept with appreciation and to most cordially reciprocate the exchange of courtesies to members in the use of the Library and rooms with the Institution of Civil Engineers, of England, and the Engineers Society of Northeastern Pennsylvania.

CALVIN W. RICE,
Secretary.

United Engineering Society

EXTRACTS FROM PRESIDENT'S ANNUAL REPORT

THE important fact of the year 1916 in the United Engineering Society is that on July 25 contracts were executed by which the American Society of Civil Engineers became an additional Founder Society and arranged to make its permanent home in the Engineering Societies Building. The contracts provide for the construction of three additional stories to the building, the American Society of Civil Engineers to contribute a sum considered equivalent to what each other Founder Society had contributed and to participate in the original Carnegie gift and have an equal share in the property with each other Founder Society.

The construction of the addition to the building is under way, $62,525.04 having been expended thereon in 1916. This work is in charge of a Building Committee consisting of H. H. Barnes, Jr., Chairman, E. G. Spilsbury, Charles Warren Hunt and Charles F. Rand.

At the request of the Founder Societies, important alterations were made to the lecture halls on the fifth floor of the building to make them suitable for social functions of the societies.

The Library of the American Society of Civil Engineers is being merged with the Library of the United Engineering Society and the Founder Societies.

At the present time the membership of the four Founder Societies is 29,000, and of associate societies 23,000, so that a total of 52,000 engineers now have their headquarters in our building.

The building is at present fully occupied.

The value of the real estate now owned by the United Engineering Society is $1,647,171.16. This sum will be increased at the end of 1917 by the amount of the cost of the addition to the building.

The income of the Society during 1916 was..	$53,062.03
The expenditure was	44,316.20
Gain for the year	$8,745.83

Funds for the benefit of the Library were obtained during the year from contributions by the societies of Civil, Mining, Mechanical and Electrical Engineers and the United Engineering Society to the amount of........ $15,542.33

From miscellaneous sources	1,751.03
The gross income from searches was	5,382.98
Total	$22,676.34

The Library expenses have been as follows:

Library Books purchased	$2,340.88
Library Binding Expense	1,442.55
Library Supplies and Miscellaneous Expense	1,379.38
Library Salaries	10,923.81
Library Photostat	1,091.02
Library New Lighting Fixtures	132.47
Library Searches Expense	5,366.23
Total	$22,676.34

Dr. James Douglas, who started our Library Endowment Fund with a gift of $5,000, has added $95,000 thereto. The total of the fund is now $102,559.70. An effort is being made to materially increase this fund, as the Library requires the income of a million dollars for its proposed development.

The securities in the Engineering Foundation Fund were sold and the proceeds reinvested to produce a higher income, as shown in detail in the Treasurer's report. The Fund now amounts to $203,374.80.

The General Reserve Fund remains unchanged at	$10,000.00
The Depreciation and Renewal Fund is now..	71,456.12
The Surplus Account December 31, 1916, is..	6,053.25

CHARLES F. RAND,
President, United Engineering Society.

Professor Carpenter to Retire

Prof. R. C. Carpenter, Past Vice-President Am.Soc.M.E., reaches the retiring age at the end of the present college year and will sever his active connection with Cornell University at that time.

Respecting his retirement, the Committee on General Administration of the Board of Trustees adopted the following resolution:

> RESOLVED, that the Trustees in accepting the resignation of Professor Carpenter express their high appreciation of his services to the University for nearly thirty years. As a pioneer in the field of experimental engineering he is held in the highest esteem by all mechanical engineers, and by his writings in this field he has made an assured place for himself in the annals of his profession. As a teacher and investigator he is affectionately remembered by many generations of students, and his retirement from the Faculty of Sibley College will be viewed with great regret by all his colleagues.

THE SPRING MEETING AT CINCINNATI

THE fundamental principles which the engineers of this country have found to be essential for the successful production of munitions will form the subject of an important sion of the Spring Meeting of The American Society of Mechanical Engineers, to be held in Cincinnati, Ohio, May 21 to 24. A year ago, when the country began to take up the question of Industrial Preparedness, the Society devoted a session of its Spring Meeting in New Orleans to a discussion of this subject. This discussion was the means of bringing out many valuable ideas—one of them that of an industrial inventory, which was later put into effect by the Committee on Industrial Preparedness of the Naval Consulting Board. As the result of this inventory, the Government now has on file important data regarding the capabilities of nearly 30,000 industrial concerns in this country to manufacture munitions in case of necessity. It is expected that the Munitions Session at the coming Spring Meeting in Cincinnati will bring out a large amount of first-hand experience in munitions manufacture from firms which have specialized in this business during the last two years. Such information will afford a valuable supplement to that contained in the Industrial Census.

The meeting is in charge of the Committee on Meetings and the Cincinnati Section Committee, and other professional features will be a Session on High-Speed Gasoline Engines, at which recent developments in connection with internal-combustion engines for automobile and aviation service will be presented; a Session on Machine Shop Practice, devoted to questions relating to design and construction of machine tools, and a Joint Session with the National Machine Tool Builders' Association, which as attested by the following letter from John T. Faig, chairman of the Cincinnati Section, will be an important event for both societies. Incidentally, Mr. Faig's letter discloses some of the good things in store for those who attend the meeting.

THE SECRETARY, THE AMERICAN SOCIETY
OF MECHANICAL ENGINEERS:

The outstanding feature of the Spring Meeting for 1917 is the fact that it will occur at the same time and place as the meeting of the National Machine Tool Builders' Association, and that one of the professional sessions and several of the entertainment features will be joint sessions. This will bring our own Society in closer touch with machine-tool building. The building of all forms of heat motors, or water wheels, of railway apparatus, of heating and ventilating devices, and of transmission machinery, seems to be recognized as belonging more clearly to the field of the mechanical engineer than does machine-tool building. This is probably due to the fact that early machine tools were largely empirical, that very little was known regarding the laws underlying the cutting of metals and the power required to remove material by means of cutting tools. Improvements in various cutting steels and more rigid demands made upon machine tools by the general introduction of interchangeable parts, have caused an extremely rapid development in the machine-tool industry, which is fast raising machine-tool building to a science.

It is natural that special emphasis should be placed on machine-tool building at the Cincinnati meeting, for the reason that an amazing development of the machine-tool industry has occurred there during the past thirty years—a development apparently out of all proportion to that which has occurred in other lines in mechanical engineering.

It seems particularly fitting, therefore, that the American Society of Mechanical Engineers and the National Machine Tool Builders' Association should meet together at Cincinnati, and that these two organizations, already closely related, should come into more intimate contact. The local session, which is to be devoted to industrial education and to welfare work, will be a joint session of these two societies and of equal interest to both. Inspection trips to the various shops will be of interest to both societies.

A word about the entertainment features will not be out of place. The Entertainment Committee is making strong efforts to provide some novel and very attractive features that will maintain the reputation made when the British Institute of Mechanical Engineers visited Cincinnati in 1904. May is usually a lovely month in Cincinnati, and the topographical features of the Queen City make it attractive to those who enjoy being out of doors in the early Spring. A number of very beautiful spots are to be visited on the automobile ride, which is scheduled for Thursday afternoon. Arrangements have been made to afford visiting members, who desire to relax, an opportunity to play golf at one of the country clubs. For those who have the latter part of the week to spend, delightful trips may be made to the famous mound

SKY LINE, CINCINNATI, OHIO

Art Museum and Art Academy, Cincinnati

known as Fort Ancient, at Morrow, Ohio, about forty miles away; to the famous Blue Grass Region of which Lexington, Kentucky, is the center, which is a veritable garden in May, and to the world-famous Mammoth Cave in Kentucky.

Beside visits to the well-known machine-tool and steam-engineering firms, a number of invitations from large concerns making steel, soap, pianos, and other commodities have been received, so that a visiting member will have a wide choice in his selection of places to visit.

In general, the practice of the Society of holding professional sessions in the mornings and devoting the afternoons to entertainment and visits will be followed, except that on Tuesday afternoon there will occur a special professional session, which will be the joint session already mentioned.

Cincinnati is well supplied with hotels of every class. As May is a busy month, however, and as Cincinnati is rather popular as a convention city, members who expect to attend the meeting are urged to make reservations at once.

John T. Faig,
Secretary, Cincinnati Section.

Information regarding transportation to Cincinnati, hotels, the program of the meeting, features of interest to be inspected, entertainment, etc., is given below, and will be followed in the next issue by the complete program giving titles of the papers to be presented and discussed at the professional sessions. In the next issue, also, will be published comprehensive abstracts of these papers, and as heretofore the papers will in addition be published in pamphlet form in advance of the meeting and may be obtained by members upon application, for the purpose of contributing discussion.

TRANSPORTATION AND FARES

The Committee on Meetings, in order to secure as large a benefit as might be derived from selecting a particular train for those of our party attending this meeting from the East, have designated the train leaving New York City by the Pennsylvania Railroad at 5.30 p. m. on Sunday evening, May 20, as the official train. The schedule of this train follows:

New York to Cincinnati

		Train No. 7.
Lv.	New York City, Pennsylvania Station	5:30 P. M.
	Manhattan Transfer	5:48 P. M.
	Newark, Market Street	5:52 P. M.
	Trenton	7:00 P. M.
	Philadelphia, North	7:38 P. M.
	Philadelphia, West	8:07 P. M
	Philadelphia, Broad Street	8:03 P. M.
	Atlantic City	4:45 P. M.
	Baltimore	8:05 P. M.
	Washington	7:00 P. M.
	Harrisburg	10:45 P. M.
	Altoona	1:38 A. M.
Ar.	Pittsburgh, Eastern time	4:30 P. M.
Lv.	Pittsburgh, Central Time	3:55 A. M.
Ar.	Columbus	8:45 A. M.
Ar.	Cincinnati, Central time	12:20 P. M.

The individual rate, New York to Cincinnati, is $18.68; the party fare, ten or more traveling together on one date and train, is $16.42. The same rates apply in the reverse direction.

There is an extra fare on the train above mentioned, between New York and Cincinnati, of $1.00.

The lower berth rate, New York to Cincinnati, is $4; upper,

Ohio River from Eden Park

$3.20; compartment, $11.50; drawing room, $14. The same rates apply in the reverse direction. A minimum of one and a half tickets are required for compartment space and two full tickets for drawing room.

All reservations for this train should be made with William V. Kibbe, District Passenger Solicitor, Pennsylvania Railroad, 487 Fifth Avenue, New York City.

Members residing in the New England States who do not wish to come by way of New York and join the party on this train, may find it convenient to take the New York Central train which leaves Boston at 2:00 p. m. Sunday, May 20, arriving in Albany at 7:45 p. m. This train leaves New York

Settling Basins, Cincinnati Waterworks

at 4:50 p. m. on Sunday and arrives in Cincinnati at 11:15 on Monday morning.

HOTELS

The Cincinnati Section Committee has selected the Hotel Sinton as headquarters for the Spring Meeting. The rates of this hotel are as given below, and members are requested *to write direct to the hotel for reservations.* Some members may prefer to stay at the Hotel Gibson, diagonally across the street from the Sinton, or elsewhere, in which case the following table of rates will be of service to them. The rates are on the European plan.

Bird Cages at Zoo

Hotel Sinton

Room without bath, one person	$1.50	per day and up
Room with bath, one person	2.00	per day and up
Room without bath, two persons	2.50	per day and up
Room with bath, two persons	3.00	per day and up

Hotel Gibson

Room with bath, one person	$2.00	per day and up
Room with bath, two persons	4.00	per day and up

Grand Hotel

Room without bath, one person	$1.00	per day and up
Room with bath, one person	2.00	per day and up
Room without bath, two persons	2.00	per day and up
Room with bath, two persons	3.50	per day and up

Rookwood Pottery, Cincinnati

TENTATIVE PROGRAM

With the meeting still six weeks off, the Meetings Committee and the Cincinnati Section Committee have practically completed the details of the program. There remain but one or two special sessions to be inserted. A slight change in the arrangements for excursions has been made over those given in the last issue of the Journal.

Monday, May 21

Morning........Registration.
Afternoon.......Registration.
Trip to hospital.
Visits to shops in Cincinnati.
Evening ....Informal gathering.
Address of welcome.
Dancing.

Tuesday, May 22

Morning.........Business Meeting.
Machine Shop Session.
Visit by ladies to Rookwood Pottery and Art Museum.
Afternoon.......Joint Session with National Machine Tool Builders' Association.
Visits to shops in Cincinnati.
Trolley ride by ladies to Fort Thomas.

Municipal Hospital, Cincinnati

EVENING ....Smoker for gentlemen.
Reception for ladies.

Wednesday, May 23

MORNING...... Munitions Session, lasting all day or else adjourning to Thursday morning.
Trip for ladies through leading stores and skyscraper.
AFTERNOON.... Boat ride for all to Fernbank Dam or Waterworks.
EVENING ....Informal dance.

Thursday, May 24

MORNING...... ..Miscellaneous Session.
Gasoline Engine Session.
Trolley ride for ladies to the Zoo.
AFTERNOON.... ..Visits to machine plants.
Motor-car ride to Mt. Storm, University of Cincinnati, Observatory and Ault Park.

Friday, May 25

MORNING...... ..Trip to Fort Ancient (Extra).
Trip to Mammoth Cave, Ky. (Extra).
Trip to Lexington, Ky. (Extra).

TECHNICAL EXCURSIONS

Among the technical features of the entertainment at the Spring Meeting will be a visit to the large new station of the

HUGHES HIGH SCHOOL, CINCINNATI

Union Gas and Electric Co., which is really of metropolitan dimensions; a visit to the Waterworks System, and a visit to the Fernbank Dam. The dam in the Ohio River, at the western city limits, is said to be the largest movable dam in the world. It is one of a series of 54 locks and dams being built by the Government in this river to make it navigable from Pittsburgh to Cairo.

Visits will also be made to some of the great machine tool factories in and near Cincinnati, and also to such great industrial concerns as the Procter and Gamble Soap Company.

PLACES OF INTEREST

Besides the engineering features of Cincinnati, those attending at the Spring Meeting will find many places of particular interest to visit.

The famous Rookwood Pottery is located on the brow of Mt. Adams, overlooking the downtown section of the city. Here the beautiful Rookwood ware is produced.

The Cincinnati University, in Burnet Woods, comprises McMicken, Cunningham, and Hanna Halls, the Van Wormer Library, Engineering Hall, Chemistry Building, Gymnasium, Power Plant and Observatory, which latter is on Mount Lookout, six miles from the center of the city. It is the only municipal university in the United States.

The Ohio Mechanics' Institute is another great educational institution. It is now housed in a magnificent new structure at Walnut, Canal and Clay Streets, which accommodates 4,000 students, and is a big factor among scientific and industrial training schools.

Cincinnati has a city hall which cost $2,000,000, and three new high schools which in architecture and appointments are not excelled in any city in the United States. The government building and custom house on Fifth Avenue cost over $6,000,000. A new municipal hospital cost $4,000,000.

Cincinnati has a system of public parks and boulevards which covers about 2,500 acres, and is now undergoing extensions and improvements. The oldest is Eden Park, located on the crest of Mt. Adams; it was once the vineyard of Nicholas Longworth, great-grandfather of Congressman Longworth.

Among points easily reached from Cincinnati are Chattanooga, Tenn., with the battlefields of Lookout Mountain, Signal Mountain and Missionary Ridge; Boonesborough, Ky., the oldest settlement established by English-speaking people in the Mississippi Valley; Lincoln's birthplace, near Hodgenville, Ky.; Mammoth Cave and Colossal Cavern; the tomb of President Harrison at North Bend; Point Pleasant, the home and birthplace of Ulysses S. Grant, and Georgetown, where the great General spent his boyhood.

Junior and Student Prizes

In the Technical Section of this issue are included papers by Howard E. Stevens, Boynton M. Green and M. Adam, which were awarded Student prizes at the Annual Meeting of the Society, December 1916.

It is hoped that these examples may stimulate those of our Junior Members and members of Student Branches who intend to enter for this year's competition, which closes on June 30, 1917, and particulars of which were published on page 153 of the February issue of The Journal and are also given in the 1917 Year Book on pages 508-9.

Any further information regarding this competition will be furnished on application to the Secretary, who will also be glad to give any suggestions to those entering this year.

Colonel Walter Katte

Col. Walter Katte, who was for fifty years active in railroad and bridge construction in this country, died in New York City on March 5. He was the first chief engineer of the Second and Ninth Avenue Elevated Railroads of the metropolis, and was identified prominently with the construction of the West Shore Railroad. His railroad experience included ten years in the service of the Pennsylvania System and twelve years as chief engineer of the New York Central Railroad. He was one of the early members of the American Society of Civil Engineers, and served twice as a director of the Institution of Civil Engineers, of London.

Mr. Katte's son, E. B. Katte, is a past Vice-President of our Society.

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER MAY 10, 1917

THE American Society of Mechanical Engineers is an organization for mutual service of over 7800 engineers and associates coöperating with engineers. The membership of the Society comprises Honorary Members, Members, Associates, Associate-Members and Juniors, all elected by ballot of the Council. Application for membership is made on a regular form furnished by the Secretary which provides for a statement of the standing and professional experience of the applicant and requires references from voting members personally acquainted with the applicant. The requirements for admission to the various grades will be furnished upon request.

Below is the list of candidates who have filed applications for membership since the date of the last issue of The Journal. These are classified according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by May 10, 1917, and providing satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about June 15, 1917.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

California

ABBEY, ALFRED B., Construction Engineer,
Standard Oil Co. of Cal., Whittier

COX, SPENCER F., Mechanic,
A. T. & S. F. R. R., San Bernardino

OTTERSON, N. E., Sales Manager,
Senn Concentrator Co., San Francisco

Connecticut

BRYANT, RAYMOND F., Assistant to Vice-Pres., and Gen. Supt.,
Yale & Towne Mfg. Co., Stamford

HUBBARD, FRANKLIN G., Vice-President,
The H. E. Harris Engrg. Co., Bridgeport

METZGER, ELMER E., General Superintendent,
Geometric Tool Co., New Haven

STARR, ADOLPH, Chief Gage Inspector,
Winchester Repeating Arms Co., New Haven

UNGAR, G. A., Technical Manager and Chief Engineer,
S.K.F. Ball Bearing Co., Hartford

Delaware

HOMEWOOD, WILLIAM T., Designing Engineer,
E. I. du Pont de Nemours & Co., Wilmington

PIERCE, H. M., Chief Engineer,
E. I. du Pont de Nemours & Co., Wilmington

Illinois

BLAINE, JOSEPH R., Mechanical Engineer and Designer,
Miehle Printing Press & Mfg. Co., Chicago

CALAME, ARMAND, Assistant Foreman Machine Shop,
Elgin National Watch Co., Elgin

MILLER, KAY C., Chief Tool Designer, Chief Inspector,
The Root & Van Dervoort Engrg. Co., E. Moline

WEBSTER, TOWNER K. JR., Vice-President,
Webster Engineering Co., Chicago

WEST, OSCAR J., Sales and Consulting Engineer, Chicago

Indiana

CROW, MARTIN E., with Crow-Elkhart Motor Co., Elkhart

HETZEL, FREDERIC V., Chief Engineer,
Link Belt Co., Indianapolis

Louisiana

BARELLI, JOHN S., Manager New Orleans Office,
Heine Safety Boiler Co., New Orleans

Massachusetts

ALFORD, FRANK R., Superintendent,
Chelsea Clock Co., Chelsea

BROOKS, JOHN C., Assistant to Vice-President,
Goodell-Pratt Co., Greenfield

GUNNING, WILLIAM A., Chief Draftsman,
American Optical Co., Southbridge

HALE, RICHARD A., Principal Assistant Engineer,
Essex Co., Lawrence

McKITTRICK, PERCY A., Office Manager,
Saco-Lowell Shops, Lowell

MILLIKEN, JAMES L., Resident Representative,
Everett Mills, Lawrence

SMITH, CLAYTON O., Sales Manager,
Norton Grinding Co., Worcester

Michigan

HARTMAN, DONALD U., Instruction Department,
Consumers Power Co., Jackson

HEAVENRICH, OSMOND D., Chief Engineer,
Detroit Pressed Steel Co., Detroit

OLSON, CHARLES W., Chief Tool Designer,
Continental Motors Corp., Detroit

PLANCHE, ETIENNE, Chief Engineer,
Dort Motor Car Co., Flint

SCHECKENBACH, JOHN A. V., Improvement Engineer,
American Car & Fdy. Co., Detroit

Minnesota

GERRISH, HARRY E., Pres.,
Morgan-Gerrish Co., Minneapolis

JOHNSTON, WAYBURN E., Valuation Inspector,
Northern Pacific Rwy., St. Paul

KOBEL, WILSON C., Assistant Chief Engineer,
Minnesota Steel Co., Power Sta., Duluth

MORGAN, GLENN C., Vice-President,
Morgan-Gerrish Co., Minneapolis

New Jersey

BROIDO, BENJAMIN N., Mechanical Engineer,
Roessler & Hasslacher Chemical Co., Perth Amboy

FREDERICK, KARL L., Vice-President,
Passaic Metal Ware Co., Passaic

PAUL, J. S., Factory Manager,
Metal Process Co., Trenton

New York

CAUTLEY, JOHN R., Engineer Export Dept.,
P. A. Frasse & Co., Inc., New York

GREEN, WILLIAM . ., Manufacturer and Representative,
American Engineering Concerns in Europe, New York

HUNTER, CHARLES F., Superintendent Repair Shop and Chief Engr. Power Plants,
Witherbee, Sherman Co., Inc., Mineville

LEONARD, ALBERT P., Assistant Chief Engineer,
Honolulu Iron Works Co., New York

McALLISTER, JOHN E., Assistant to President,
Liberty Fuse & Arms Corp., Long Island City

MacFARLAND, EDWARD H., Steam Turbine Inspector,
General Electric Co., Schenectady

MAIS, ALBERT F., Chief Engineer,
Fulton Motor Truck Co., Farmingdale, L. I.

MARTIN, JOHN F., Superintendent,
Neptune Meter Co., Long Island City

MORROW, JAMES E., Secretary and Manager of Production,
Morrow Mfg. Co., Elmira

DE NEMETH, ZOLTAN, Engineer Power Plant Designs,
James Stewart & Co., New York

SHRADY, CHARLES D., Engineer,
Van Siclen & Co., New York

SHAW, HUBERT A., Metallurgist,
American Can Co., Geneva

WAGNER, JAMES J., Engineer,
New York Central R. R. Co., New York

Ohio

BRANSON, James E., Assistant to J. D. Lyon, Cons. Engr., Cincinnati

PEARSON, James R., Vice-President, The Acme Machine Tool Co., Cincinnati

SHUTT, Milo, Mechanical Draftsman, The Alliance Machine Co., Alliance

STEVENS, William N., Machine Tool Design, Cincinnati Milling Mch. Co., Cincinnati

WALMSLEY, Harold M., Resident Engineer, Sargent & Lundy, Cincinnati

Pennsylvania

HENRY, Frank E., Construction Engineer, American Sheet & Tin Plate Co., Pittsburgh

LELAND, Edward D., Superintendent Compressing Stations, Philadelphia Co., Pittsburgh

LIVERSIDGE, Horace P., Operating Engineer, The Philadelphia Electric Co., Philadelphia

SCHULTZ, Walter F., Chief Engineer, Driggs-Seabury Ordnance Co., Sharon

WEBSTER, Harry D., Mechanical Engineer, Bessemer & Lake Erie R. R. Co., Greenville

WHITCRAFT, Arthur, Sales Engineer, American Manganese Steel Co., Pittsburgh

Tennessee

BADGER, Harry S., Superintendent Power Sta. and Sub-Sta., Nashville Rwy. & Light Co., Nashville

Texas

MOELLER, William, Suprintendent, Texas Portland Cement Co., Houston

Vermont

FULLAM, Eben J., Secretary, The Fellows Gear Shaper Co., Springfield

Virginia

LEE, Cazenove G., Jr., with E. I. du Pont de Nemours & Co., City Point

Wisconsin

BROWN, Arthur J., Chief Draftsman Electrical Dept., Allis-Chalmers Mfg. Co., Milwaukee

Canada

CAMERON, N. C., Chief Engineer, Imperial Tobacco Co. of Canada, Ltd., Montreal

France

SCHUTZ, Harry M., Engineer, Niles-Bement-Pond Co. of U. S. A., Paris

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Delaware

BANKER, Walter B., Resident Engineer, E. I. du Pont de Nemours & Co., Wilmington

Illinois

MARLOW, Frank W., Chief Engineer, Armour & Co., Chicago

MILLER, Joseph S., Mechanical Engineer, Kewanee Boiler Co., Kewanee

Massachusetts

HAMILTON, Don A., Mechanical Engineer, John Bath & Co., Inc., Worcester

Michigan

GILLOOLY, John H., Draftsman, Steere Engineering Co., Detroit

KAMMERER, Nelson C., Chief Draftsman, Metalwood Mfg. Co., Detroit

Nebraska

SLOMAN, Hubert E., Assistant Superintendent of Buildings and Construction, J. L. Brandeis & Sons, Omaha

New York

CONLEY, Murray C., Mechanical Engineer, Henry L. Doherty & Co., New York

HUNICKE, Clarence C., Patent Attorney and Attorney at Law, New York

LOGAN, Orwell, Chief Engineer, Jensen Creamery Machinery Co., Long Island City

McHOLLAN, James A., Assistant Engineer, The R. P. Bolton Co., New York

MEAD, Frank R., Assistant to Chief of Department of Gauges, L. R. Kenyon, Munitions of the British Government, New York

MORLEY, Marcus D., Assistant to Engineer of Tests, Edison Electric Ill. Co., Brooklyn

SERRELL, John J., Vice-President, Smith-Serrell Co., Inc., New York

SMITH, Albert T., Manager, The R. U. V. Co., New York

TERWILLIGER, David M., Engineer of Tests, Operating Department, Edison Elec. Ill. Co., Brooklyn

WHEELER, William H., Purchasing Engineer, Austin Baldwin & Co., New York

Pennsylvania

KIRK, Donald, Draftsman, Carnegie Steel Co., Homestead Works, Munhall

WADD, Roy J., with Shephard Electric Crane & Hoist Co., Pittsburgh

Virginia

DUFFEY, Paul R., 1st Assistant Master Mechanic, Mathieson Alkali Works, Saltville

Wisconsin

HENSZEY, Roy O., Engineer and Architect, Carnation Milk Products Co., Oconomowoc

MOYER, Will D., Public Utility Inspector, Wisconsin R. R. Comm., Madison

FOR CONSIDERATION AS JUNIOR

Alabama

HALLER, Louis G., Manager Birmingham Office, The Walsh & Weidner Boiler Co., Chattanooga

Connecticut

BACON, David L., Plant Engineer, The Greist Manufacturing Co., New Haven

Florida

TILLIS, H. Rhett, Chief Engineer, American Agricultural Chemical Co., Pierce

Illinois

ARMACOST, Wilbur H., Engineer, Armour & Co., Chicago

BYANSKAS, John M., Testing Engineer, Mech. Dept., Armour & Co., Chicago

PARRIGIN, Homer, Steam Expert, Illinois Steel Co., Joliet

Indiana

KNOWLTON, Chase H., Special Engr., Motive Power Dept., C. C. C. & St. L. Rwy, Indianapolis

Massachusetts

LINDBLOM, Herbert R., Assistant to Foundry Supt., Saco-Lowell Shops, Newton Upper Falls

New York

BAACK, Henry J., Laboratorian, Navy Department, Navy Yard, Brooklyn

BEARD, Theodore H., Instructor Mech. Engrg., New York University School of Applied Science, New York

BENEDICT, Byron W., Construction Engr., American District Steam Co., North Tonawanda

CARLSON, Clarence A., Designing Engineer, Canady-Blaisdell Corp., New York

De LEMOS, Frederick P., Assistant to Chief Engineer, Automatic Sprinkler Co. of America, New York

HORTON, Frank W., Designing Draftsman, National District Telegraph Co., New York

LEA, Robert B., Manager Stabilizer Dept., Sperry Gyroscope Co., Brooklyn

SQUIRE, Milford B., with General Electric Co., Schenectady

Ohio

ATWELL, Norbert S., Inspector of Meters, Ohio Fuel Supply Co., Columbus

TAYLOR, Robert M., Works Engineer, The American Tool Works Co., Cincinnati

TOMLINSON, C. Sprague, Assistant to Power Plant Engineer, The Firestone Tire & Rubber Co., Akron

WINBIGLER, Howard D., Assistant Mechanical Engineer, Faultless Rubber Co., Ashland

Pennsylvania

FURBUSH, Grant E., Instructor, Dept. of Indus. Engrg., Penn. State College, State College

GOLDSMITH, Lester M., Engineer of Tests, Atlantic Refining Co., Philadelphia

MOODY, William M., Engineer, I. P. Morris Co., Philadelphia

REYNOLDS, Lloyd C., Assistant Steam Engineer, Worth Bros. Co., Coatesville

SWEETEN, Allen W., Designing Engineer, Simplex Valve & Meter Co., Philadelphia

Tennessee

WEIGEL, Rothe, Mechanical Engineer, La Follette Coal & Iron Co., La Follette

Wyoming

CHRISTIAN, Ben, Mechanical Draftsman, Great Western Sugar Co., Denver

Canada

JENTZ, Carl D., Engineer, St. Maurice Paper Co., Cape Madeleine, P. Que.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

Minnesota

BUFFINGTON, Harry C., Motor Engineer, Minneapolis Steel & Mchy. Co., Minneapolis

PROMOTION FROM JUNIOR

Connecticut

MacEWAN, Thomas S., Manager Sales of Mchy. Dept., S.K.F. Ball Bearing Co., Hartford

New Jersey

CHEETHAM, Joseph H., Chief Mechanical Engineer, McNab & Harlin Mfg. Co., Paterson

New York

GILLETT, Lowry, Power Engineer, General Chemical Co., New York

Massachusetts

ADAMS, Kilburn E., with Edison Elec. Ill. Co., Boston

Missouri

DOWNES, Nate W., Mechanical Engineer, Kansas City School District, Kansas City

SUMMARY

New applications	118
Applications for change of grading:	
Promotion from Associate-Member	1
Promotion from Junior	5
Total	124

NECROLOGY

CHARLES ALEXANDER CANDA

Charles Alexander Canda was born in Summit, N. J., on June 18, 1869. He received his education in the public schools and Stevens Institute, graduating from the latter in 1893. He soon after became associated with the Brush Electric Light Co., New York, where he remained until 1899. During this time he designed a direct-current arc lamp whereby the top and bottom carbons were controlled in the head of the lamp.

In the latter part of 1899 he affiliated with the Canda Manufacturing Co., manufacturers of automobiles, serving in the capacity of assistant to the superintendent, acting superintendent from 1900 and superintendent in 1901. Early in 1902 he assumed the duties of secretary and became part owner of the Chrome Steel Works, Chrome, N. J., holding this office at the time of his death.

Mr. Canda was granted a number of patents, among them being a clamping device for tappets, wheels or shaft couplings, and an improvement on a machine for making tubes and tires.

Mr. Canda became a member of the Society in 1916. He died at his residence in Elizabeth, N. J., February 8, 1917.

FRANK EUGENE HOLT

Frank Eugene Holt was born at Holyoke, Mass., in 1856. He served his apprenticeship with Eddy and Stone, of Worcester, Mass., and between 1876 and 1893 was associated with The Washburn & Moen Manufacturing Co., during which time he was in charge of their Union Street shop, and did work in connection with the erection of rolling mills for that company. In 1893 he accepted the position of master mechanic with the Spaulding & Jennings Co., and when this plant was absorbed by the Crucible Steel Company of America, he went to the Singer Manufacturing Co. to design and erect a rolling mill to produce small steel shapes, and thereupon was put in charge of the power houses of the company, at the Elizabethport factory, and performed advisory duties in connection with the power operation of their plant at St. Johns, Canada.

At the time of his death, Mr. Holt was President of the Singer Club, and a member of the Singer Engineering Society. He joined the Society in 1900. He died on February 4, 1917.

CAPTAIN WILLIAM HENRY JAQUES

Capt. William Henry Jaques was born in Philadelphia, Pa., December 24, 1848. He received his early education in the schools of New Jersey and entered the United States Naval Academy as midshipman in 1863. He graduated from the Academy with honors in 1867 and was detailed for active service immediately. He became ensign in 1868, master in 1870, and lieutenant in 1871. At various times he performed duties as aide to the President, the Secretary of the Navy, and the Commandant of the New York Navy Yard.

Between 1870 and 1874 he was assistant in the United States Coast Survey; from 1874 to 1878 he assisted the New York Board of Education in technical education; in 1881-1882 was assistant inspector of ordnance; and from 1883 to 1885 member and secretary to the Senate Committee on Ordnance and Warships. During this time he succeeded in introducing the system of fluid compression and hydraulic forging of heavy masses of steel, and was the inventor of many improvements in the manufacture of heavy ordnance and armor and the leading exponent of employing nickel in steel.

Captain Jaques resigned his commission in the Navy in 1887 to accept a position with the Bethlehem Steel Co. as ordnance engineer. In 1894, having successfully carried out the various developments he had advised, he retired. Soon after he associated himself with Horace See, eminent engineer and architect, in general engineering and consultation in connection with the manufacture and treatment of guns, armor, and other war material. In 1895, at the request of the governor of New Jersey, he began the organization of a naval reserve for that state and was commissioned captain. He held this command until 1898, when loss of health compelled him to resign.

Although he had already done his full share in bringing the ordnance and armor of the United States to a high standard of excellence, he undertook in 1897 the development of submarine torpedo boats and accepted the presidency of the Holland Submarine Boat Co. In 1909 he became president of the Hampton Water Works Co., Little Boar's Head, N. H., and in 1913 president of the Progress Mfg. Co., Boston, Mass., which offices he held at the time of his death, October 23, 1916.

Captain Jaques was the author of numerous monographs and books on heavy ordnance, armor, torpedoes, solar radiation, etc., and was an authority on water engineering. He was one of the international jury on marine transportation and war material at the Columbian Exposition of 1893.

Besides being a Member of the Society (1893), he was also a life member of the Society of Naval Architects and Marine Engineers, and a member of the American Institute of Mining Engineers, the American Society of Civil Engineers, the Iron and Steel Institute, the Institute of Civil Engineers (Great Britain), the Institution of Mechanical Engineers (Great Britain), the Institution of Naval Architects (Great Britain), and other organizations.

PAUL H. KENDRICKEN

Paul H. Kendricken was born in Galway, Ireland, in 1834. He set sail for America as a lad of seven, and landed in Boston in 1842. In 1852 he went as an apprentice to Walworth and Nason, then considered pioneers in steam and hot-water heating of houses, and then became associated with the Union Steam Gauge and Low Water Detector Co. In 1859 he was put in charge of the steam works of the Massachusetts Steam Heating Company, and was later promoted to acting superintendent.

Not long after, he entered the Naval Service as third assistant engineer, was promoted to second assistant engineer, and remained in active service until the end of the war. At its termination he became associated with Clagston and Company, for whom he acted as superintendent. After some changes, the firm became Ingalls & Kendricken, and under Mr. Kendricken's guidance developed into a successful business. The firm was incorporated in 1905, Mr. Kendricken remaining as president and treasurer until the time of his retirement, five years ago.

Mr. Kendricken held various public offices, including that of councilman, alderman, state senator, park commissioner for the City of Boston, etc. He was also a member of the Executive Committee of the National Association of Master Steam Fitters.

He became a member of the Society in 1910.

JOSEPH STEHLIN

Joseph Stehlin, who was born in New York City in 1875, received his early education in the public schools here, and later in the Stevens Preparatory School and the Stevens Institute of Technology, graduating from the latter in 1898 with the degree of M.E.

Directly upon leaving school, Mr. Stehlin entered the drawing-room of P. Pryibil and soon after that of C. W. Hunt & Co. His shop experience was obtained while with J. Rupert and as assistant engineer with the Nestle Food Co., 1899. In 1900 he became associated with the N. Y. C. & H. R. R. R. as assistant mechanical engineer, and in 1903 became mechanical engineer, superintending erection of power stations, cooling plants, water stations, lighting, and power and steam equipment of yards and buildings. He severed his connection with the N. Y. C. & H. R. R. R. in 1906 and founded the Stehlin-Miller-Henes Co., steam and electric engineers and contractors. In 1908 he became also associated with the Farmers Feed Co., of which his father was president, and in 1909, upon the death of his father, he succeeded to the presidency of the company and continued so until the time of his death, January 22, 1917.

Mr. Stehlin was elected an Associate in the Society in 1905.

KENNETH TORRANCE

Kenneth Torrance was born in Brooklyn, New York, in 1863. He went to Stevens High School for one year and then to Stevens Institute, and graduated with the class of 1884. He remained an active alumnus throughout the rest of his life and founded an enthusiastic association of Stevens alumni in Schenectady.

After leaving college he went to the Worthington Pump Co. and was later with the Brooklyn Water Works as Superintendent of the Ridgewood and all the Long Island pumping stations, which position he filled until 1906. He then joined the General Electric Co. to take charge, at its Schenectady Works, of its power stations, pumping stations, water, steam and compressed air systems, heating, etc. He carried out the reconstruction of the entire heating system for this works and was responsible for the design of all heating for the many new buildings erected at this works during his connection with the company. He carried out extensive additions to the power plants which resulted in very successfully meeting most extraordinary requirements in connection with emergency power supply, steam for testing, etc. He was actively connected with the development of the steam flow meter.

Kenneth Torrance had a rare gift for handling men. In Brooklyn and later in Schenectady he held the loyalty and respect of those under him as few men do. He had a host of friends, and wherever he went he made more.

He was a member of the Society for many years and also of the American Waterworks Association, the Society of Engineers of Eastern New York, the Schenectady Stevens Club, the Delta Tau Delta fraternity, the Mohawk Club, and the Mohawk Golf Club.

He died on September 13, 1916, at Mount Kineo, Maine, where he had gone to convalesce after a severe illness.

AMONG THE SECTIONS

SINCE the last issue of The Journal went to press, the President made an extended trip, which took him as far west as the Minnesota Section whose headquarters is at Minneapolis-St. Paul. En route he visited the Sections at Buffalo, Chicago and Indianapolis. At each of these places he received a rousing welcome and his spirited address on Service to the Country in This Crisis brought forth enthusiastic responses.

Although he has as yet been in office less than four months, Dr. Hollis has already visited ten Sections and eight Student Branches, addressing several thousands of engineers. He has spent a total of thirty-four days in these activities, which are additional to the time consumed in the attendance at Council and various committee meetings and in carrying on a voluminous correspondence relative to the Society's business.

As the present issue of The Journal goes to press the Secretary is starting on a trip to visit Sections and Student Branches not covered by other officers during the current fiscal year. These will include the Sections at Cincinnati, Chicago, Milwaukee, and probably Kansas City, where the members are considering organizing a Section. Several Student Branches will also be covered.

These data will serve to emphasize the national importance of the Society, which now boasts of twenty Sections located in sixteen States of the Union. It is the ambition of the Secretary that each Section and Student Branch receive a visit at least once a year by one of the Executive Officers of the Society.

Recently a visit was made by Prof. L. P. Breckenridge to the Sections at Atlanta and New Orleans, and these places wholesomely entertained the representative of the New Haven Section, and received in return the benefit of many valuable suggestions as to the methods the New Haven Section pursues

in developing engineering coöperation in Southern New England.

In the March issue of The Journal on page 241 there appeared a report presented at the Conference of Section Delegates at the last Annual Meeting, entitled Suggestions Regarding Local Section Activities. Mr. D. Robert Yarnall was one of the Committee to prepare this report and his name should have been included with Messrs. H. R. Setz and W. G. Starkweather.

SECTION MEETINGS

ATLANTA

February 5—The members of the Atlanta Section devoted February 5 and 6 to the entertainment of Prof. L. P. Breckenridge, Mem.Am.Soc.M.E., who visited their city. At a luncheon tendered him, Professor Breckenridge spoke of the advantages of the different sections and told of the activities of the New Haven Section. It was felt that his talk was a great incentive to the members of our Section.

Earl F. Scott,
Section Chairman.

BALTIMORE

March 13—A meeting of the Baltimore Section was held in the Engineers' Club and was addressed by John T. Broderick. The following resolution was moved and seconded and adopted by the Section, subject to approval by the Council of the Society.

> "In view of the grave crisis which our country is facing, and in recognition of the stand recently taken by the President of the United States for the protection of American rights and American lives on the sea,
>
> "BE IT RESOLVED that we, the members of the Baltimore Section of the American Society of Mechanical Engineers, at a meeting held Tuesday, March 13, 1917, first do pledge ourselves to the support of the President and Congress in maintaining our rights; and, second, we pledge our services to our country in case it is forced into war as the only means of securing and maintaining these rights.
>
> "BE IT FURTHER RESOLVED that a copy of this resolution be sent to the President, at the White House, at Washington, and to Senators and Representatives."

Mr. Broderick, who holds the position of Supervisor of Special Bureaus on the Baltimore and Ohio Railroad, gave an address on Safety Work on this road, showing moving pictures that this company uses to impress the Safety First idea on the men. Mr. Broderick said in part: "In the 'Safety First' movement which swept the country during the fall of 1911, the Baltimore and Ohio was the first company in the East to organize a definite campaign against personal injury to employees, renewing its efforts to safeguard passengers and its property. In the words of President Daniel Willard, the principle took precedence 'over everything else,' and still does with unabated sincerity of purpose.

"'To perpetuate the propaganda of Safety First, the Railroad has resorted to every practical means of education—precept, instruction, example, proof and discipline. A General Committee was organized in Baltimore, serving on which were the officials best adapted to the preachment of safety. Upon the various divisions, Divisional Committees were formed consisting of the superintendents and staffs as permanent members and men from the ranks selected every three months. The General Committee held mass-meetings at principal terminal points along the system, attracting large crowds of railroad men, at which addresses were made by the Committeemen and stereopticon views shown, all portraying various phases of the subject—Safety—and its allied subject—'Health and Sanitation.' Such Division Committees meet once each month, and at these gatherings receive and record many of the suggestions made by the employees themselves. The men enter into the spirit of the campaign, and divisions vie with one another to head the list of decreases in accidents. Last year the men on these Committees made 17,000 suggestions for improving working conditions, 96 per cent of which were recorded and acted upon. . .

"Through the maintenance of the 'Safety First' Bureau, which has direct charge of this work, supervising the organization and work of the Divisional Committees, thoroughly organized and sustained efforts are being made to reduce accidents on every division of the System to the minimum."

A. G. Christie,
Section Secretary.

BOSTON

March 8—A joint meeting was held by the Boston Section and the American Institute of Electrical Engineers. W. B. Potter, Mem.Am.Soc.M.E., spoke on Electric Transmission for Motor Cars.

Mr. Potter illustrated his lecture with many interesting lantern slides, dividing his subject into the application of this system of propulsion to railroad cars and to automobiles, and tracing the development of the system within the last two or three years to its present condition.

W. G. Starkweather,
Section Secretary.

BUFFALO

April 14.—The Engineering Society of Buffalo will hold a meeting at the Hotel Statler, at which time there will be a discussion of Educational Systems and Apprenticeship Systems.

February 15—A resolution was passed for a preparedness post-card canvass, asking each of the 600 members to state in what way he would be most proficient in time of war and if he would be willing to volunteer his services.

Charles F. Kettering, Mem.Am.Soc.M.E., Vice-President of the Dayton Engineering Laboratories, gave a most interesting lecture on the evening of February 28, taking as his topic Pure Science Applied to Engineering, mixing humor, wit, politics, story and reminiscence with technical considerations. He showed many articles of common commerce which science has made possible, finding a substitute for scarce genuine material. He discussed the fundamental side of research, and his reminiscence concerning many problems of the experimental research engineer was of an interesting nature.

March 7—An enthusiastic and very large audience listened to addresses on March 7 by Dr. Ira N. Hollis, Pres.Am.Soc.M.E., John Younger, Mem.Am.Soc.M.E., William Elmer, Mem.Am.Soc. M.E., Major Frank S. Sidway, A. Conger Goodyear, Evan Hollister, Charles M. Manly, Mem.Am.Soc.M.E., and Herbert A. Meldrum.

Dr. Hollis spoke on Services to Our Country in This Crisis, explaining the condition of this country and impressed upon his audience that the only way to overcome this inefficient state is by unity of purpose, coöperation with our fellow workers, loyalty to our country and preparation for war against war, and showed the part the engineer must take. Mr. Younger told of classes being formed for the instruction of men in field fortification, telephony and transportation so that if necessary this city will be able to send trained men into the field. Mr. Elmer followed with a description of the part the railroads will play in time of war. Major Sidway urged action on the training of youth. Mr. Meldrum said that the mobilization of the troops on the border had shown the great need for military training and that it was time for the country to act. Mr. Goodyear urged the furtherance of the officers' reserve corps and defined its duties. Mr. Hollister spoke on compulsory military training, followed by Mr. Manly, a pioneer of aviation in the United States, who advised people to show their sentiments on the topics of to-day by continually urging their congressmen to carry out their program.

Louis J. Foley,
Assistant to Secretary.

DETROIT

April 20—J. W. Lieb, Mem.Am.Soc.M.E., will be the speaker at the meeting of the Detroit Section, taking as his subject Leonardo da Vinci—Artist, Philosopher and Engineer.

INDIANAPOLIS

March 12—A meeting held by this Section with the Engineers' Club of this city was addressed by Ira N. Hollis, Pres., Am.Soc.M.E., the subject discussed was the Relation of the Engineer in Civil Life to the Present National Crisis. A committee was

formed to offer the services of the Engineers' Club, with which the Section is affiliated, to the government and also to the state and city authorities for such service as the emergency might indicate as the most valuable for them to render.

W. H. Insley,
Section Chairman.

MERIDEN

March 9—At the regular monthly meeting of the Meriden members of the A.S.M.E. on March 9, Frank L. Rowntree, Mem. Am.Soc.M.E., spoke of the growth of the Society in Meriden; Charles N. Flagg, Jr., Mem.Am.Soc.M.E., read a paper on the Isolated Power Plant, after which the meeting was opened for general discussion, remarks being made by J. A. Hutchinson, Mem.Am.Soc.M.E., D. P. Griswold, Herman Minkwitz and C. K. Decherd, Mem.Am.Soc.M.E., and others. The next meeting will be held on April 5.

NEW ORLEANS

April 2—The New Orleans Section will hold a meeting, at which the subject for discussion will be Preparedness. The principal paper will be given by A. M. Lockett, Mem.Am.Soc.M.E. and member of the Naval Consulting Board which made the recent industrial census for the army and navy.

NEW YORK

March 13—Mobile Armaments formed the subject of a paper by Andrew M. Coyle, Mem.Am.Soc.M.E., before the New York Section at this meeting. The timeliness of the subject was responsible for an unusually large attendance.

Mr. Coyle, who is with the Board of Coast Defense Engineers, U.S.A., outlined the necessity for an adequate system of mobile guns of both large and small calibre, mounted on railway cars, that could be quickly moved from place to place to protect the numerous stretches of coast line between the fortifications which now guard the approaches to our important harbors. He showed a number of pictures of armored cars now in use along the European battlefronts, and told in a general way what is being done in this country. The speaker showed the various means that have been developed to take up the recoil and briefly mentioned a new device now being worked out by the army engineers in which this problem has been greatly simplified. In the discussion that followed, L. W. Luellen described and illustrated the Luellen-Dawson system of mounting mobile guns—a system that requires permanent concrete bases over which the car is run and the gun is mounted.

A. D. Blake,
Section Secretary.

PHILADELPHIA

April 24.—There will be an entertainment for Dr. Ira N. Hollis, Pres. Am.Soc.M.E., by the Philadelphia Section at the Engineers' Club.

March 15—A joint meeting with The Franklin Institute was addressed by Jerome C. Hunsaker, assistant naval constructor, Navy Department, Washington, on Design, Construction and Equipment of a Modern Military Aeroplane.

Mr. Hunsaker spoke of the importance attached to the mastery of the air by those engaged in the present conflict in Europe and the efforts made to gain and maintain this prestige, emphasizing the extreme rapidity with which different types were evolved, due to the keen competition for supremacy. The speaker illustrated his remarks with lantern slides, and moving pictures were also shown of the first air flights in this country by the Wright brothers and of various air crafts in Europe, among the latter of which was the destruction of a German aeroplane by French machines, and a 9000 ft. drop in a parachute from a kite balloon.

W. R. Jones,
Section Secretary.

PROVIDENCE

April 23—The Providence Engineering Society will hold a meeting which has been arranged by the Efficiency and Scientific Management Department. The subject will be Routing-Principles, Machine Symbols, etc.

ST LOUIS

April 18—At this meeting one of the leading refrigeration engineers of St. Louis will give a talk on Refrigeration Problems of a Modern Hotel.

STUDENT BRANCHES

THAT the spirit of coöperation existing in the engineering profession is extending to our coming engineers, is reflected in the plans for joint meetings of Student Branches on the Pacific and Atlantic Coasts and in the Middle West.

On March 24 a joint meeting of the Branches at Leland Stanford University and the University of California was held at the latter university. As this is taking place as The Journal goes to press a detailed account of it must be deferred until the May issue.

Meanwhile, in the East, a committee of Student Members is at work perfecting plans for a joint meeting of the Branches at Brooklyn Polytechnic Institute, Columbia University, Lehigh University, New York University, Rensselaer Polytechnic Institute and Stevens Institute of Technology. Representatives of Cornell University and Ohio State University will also probably be present. In all, more than three hundred students are expected to attend, making this the largest meeting of students ever held under the auspices of the Society.

The meeting will be held at the Engineering Societies Building in New York on Friday, April 13. A professional session will begin at 5 p. m., which will be addressed by Prof. Arthur M. Greene, Jr., Member of Council Am.Soc.M.E., and Prof. Lionel S. Marks, Mem.Am.Soc.M.E., and probably also by Prof. Robert H. Fernald, Manager Am.Soc.M.E., Prof. Charles E. Lucke, Mem.Am.Soc.M.E., and General Leonard Wood.

A buffet supper will then be served, followed by a smoker. During the evening, entertainment will be furnished by college glee clubs, mandolin and banjo club, professional entertainers, etc., and light refreshments will be served.

At the Spring Meeting in Cincinnati (May 21-24) a third joint meeting of Student Branches will be held. This will take place at the University of Cincinnati, and it is expected that all of the Student Branches in that Section of the country will participate, including those at the University of Cincinnati, Purdue University, Ohio State University, Case School of Applied Science, Carnegie Institute of Technology, University of Pittsburgh and State University of Kentucky. This is the first time such a gathering has been held in connection with a general meeting of the Society, and it is hoped all branches who can do so will make every effort to participate.

During the past month the list of Student Branches was brought to a total of forty-five by the addition of the University of Oklahoma, at Norman, Okla. Prof. J. H. Felgar, Mem.Am.Soc.M.E., Dean of the College of Engineering and Director of the School of Mechanical Engineering, has been appointed Honorary Chairman of the Branch.

ARMOUR INSTITUTE OF TECHNOLOGY

January 31—The meeting of the Student Branch of the Armour Institute of Technology was devoted to discussions by students on subjects of mechanical interest. N. Steindler explained in detail the Construction of a Water Softener. B. Robecheck followed with a paper on Heat and Emulsion Test of Oils. Mr. Kerr's subject was The Compression of Air and Mr. Bretting told of the By-Products of the Forests.

On Wednesday evening, February 14, Prof. George F. Gebhardt, Mem.Am.Soc.M.E., spoke on Advice to the Engineer, which was received with much appreciation by the members.

Mr. Sweniford and H. S. White were the speakers on February 28. Mr. Sweniford gave an illustrated talk on Safety Engineering, explaining the different ways in which accidents occur and may be lessened. His illustrations showed many ways of protecting machines in machine and wood-working shops. Mr. White followed with a very clear description of the Wood Dual Electric.

A smoker was held on March 7, to which both freshmen and sophomores were invited. This was a form of get-together movement in which each member of the branch endeavored to make the lower-classmen feel that they would be cordially welcomed at all meetings and aided in taking up the work when their turn came.

E. W. Harris,
Branch Secretary.

BUCKNELL UNIVERSITY

March 5—The Student Branch of Bucknell University held its last regular monthly meeting, F. E. Benedict and C. J. Hay giving the addresses.

Mr. Benedict gave a very comprehensive talk on Railroad Machine Shop Practice. He was followed by C. J. Hays, who spoke on The Modern Gas Producer Practice, giving a detailed description of a modern plant and also some data showing the rapid development of the industry in the last decade.

C. M. Kriner,
Branch Secretary.

UNIVERSITY OF CALIFORNIA

February 14—On this date Mr. Chilcot '15 related his experiences as a scientific manager, taking the members theoretically through both the Chalmer and Ford Automobile Works and comparing the efficiency of the plants in the East with those of the West.

At a meeting on February 28, Professor Tour of the Mechanics Department of the University, read a paper on Entropy and its relation to Temperature. The pressure-volume analogy to entropy and temperature aided materially in making clear to the members just what entropy is.

A joint banquet is being planned with the Leland Stanford Jr. University Student Branch for the evening of March 24.

John H. Fenton,
Branch Secretary.

CARNEGIE INSTITUTE OF TECHNOLOGY

February 14—The regular monthly meeting of the Student Branch of the Carnegie Institute of Technology was held, when Prof. G. H. Follows, head of the Department of Machine Design, addressed the students on The Bull's Eye; Hitting It, Chasing It, Missing It, Often. He opened his talk with a description and brief history of the science of archery and likened the aims, successes and failures of the engineer to meet his goal to the archer's attempt to strike the bull's eye of the target. He pointed out that while all engineers strive to make a bull's eye, there are very few who can predict before a machine is built just what it will do when put into operation. Professor Follows concluded by recounting many interesting and some rather amusing experiences he has had during his career as a mechanical engineer.

J. H. Davis,
Branch Secretary.

CASE SCHOOL OF APPLIED SCIENCE

February 7—A regular meeting of the Student Branch of the Case School of Applied Science was held at the Case Club. John E. Washburn, Mem.Am.Soc.M.E., of the National Carbon Co., of Cleveland, O., gave a practical and interesting talk on the Heat Treatment of Iron and Steel. Mr. Washburn has had much opportunity to observe the peculiar characteristics of our industrial metals and was therefore in position to cite many interesting examples of the behavior of steel under heat treatment. To illustrate extreme properties obtainable by heat treatment, he displayed two rods made from the same piece of stock but differently treated. One of the rods possessed such strength that when secured in a vise, it could not be bent by one man's pulling at a distance of several feet from the jaws; on the other hand, the other was so weak that it could be broken by the fingers. The latter sample, he explained, if properly reheated and treated could be made as strong as the first.

March 14—Frederic A. Parkhurst, Mem.Am.Soc.M.E., was a guest of the Student Branch of Case School of Applied Science at their dinner and meeting.

Scientific Management was the topic of Mr. Parkhurst's talk. He traced the origin and development of the Taylor principles and described the elements requisite for the successful operation of that system. Mr. Parkhurst, who is organizing engineer of the Aluminum Castings Co., is to deliver a series of lectures on the same subject to the senior mechanical engineers, this being the initial talk.

A. Treuhaft,
Branch Secretary.

UNIVERSITY OF CINCINNATI

February 16—At the regular monthly meeting of the Student Branch of the University of Cincinnati, H. S. Ernst and A. W. Schneider, both seniors, gave the addresses. Mr. Schneider spoke on Mining Methods in Anthracite Coal Fields of the Lehigh Coal & Navigation Company in Pennsylvania. He pointed out the various duties and responsibilities of mechanical engineers in keeping all equipment in good repair and operation with shut downs. Mr. Ernst followed with Modern Automobile Production at the Willys Overland Company of Cleveland, Ohio. Starting with the parts of the car from raw stock, he added each part in its turn of assembly, until the car was completed. Designs, methods of machinery and intricate parts of the construction were fully explained by Mr. Ernst.

Henry A. Wolsdorf,
Branch Secretary.

COLORADO STATE AGRICULTURAL COLLEGE

February 19—The Student Branch of the Colorado State Agricultural College held a meeting, at which time the speakers were E. C. Johnson, M. L. Gorton and Prof. L. D. Crain, Mem.Am.Soc.M.E.

Mr. E. C. Johnson gave a paper regarding the methods and systems used in the Denver Rock Drill Machinery & Manufacturing Co. Mr. Gorton gave a talk in the form of advice regarding the value of summer work and the advantages gained which the college course cannot give. Professor Crain told of the methods used at other institutions which he visited recently, giving advantages and points of comparison, thus bringing those present into closer touch with other institutions doing a similar work.

E. C. Johnson,
Branch Secretary.

COLUMBIA UNIVERSITY

King of the Rails was the subject of the highly interesting and instructive moving picture shown before the United Engineering Society of Columbia University. Prof. W. I. Slichter, Mem.Am.Soc.M.E., and Professor of Electrical Engineering at the University, accompanied the picture with explanatory notes. It included a historical review of the transportation field, leading up to the development of the electric operation of the Chicago, Milwaukee and St. Paul R.R. over the Continental Divide. Professor Slichter gave some very interesting data concerning this development and went thoroughly into the scheme of power distribution.

John L. Kretzmer,
Branch Chairman.

UNIVERSITY OF ILLINOIS

February 22—The Development of the Locomotive in the United States since 1829, was the subject of a paper, with slide illustrations, by J. H. Westbay, '17. Announcement that four prizes for the best papers delivered before the Branch and sent to the judges in manuscript form, would be given by the Pi Tau Sigma, the honorary mechanical engineering fraternity at the University, was made at this meeting.

March 8—G. L. Grimes, President of the Midland Machine Co., was the speaker. Mr. Grimes explained the special types of machines of his design and told of the manner in which the necessity of the various machines became apparent. The talk was accompanied by slides and motion pictures showing several of these machines in action and the accuracy necessary in making a block cylinder mold was well brought out.

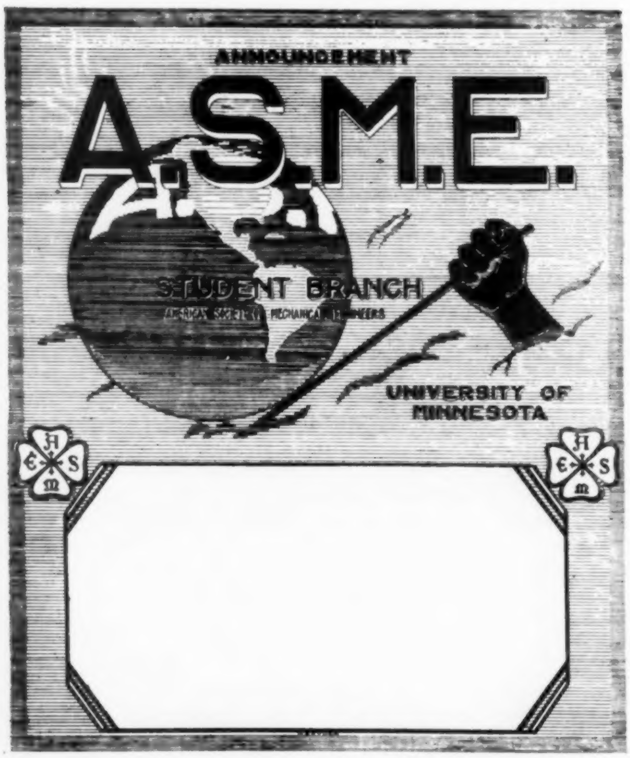
H. C. DIESERUD,
Branch Secretary.

JOHNS HOPKINS UNIVERSITY

February 12—The Engineering Society of Johns Hopkins University held its second meeting of the year, with the Student Branch of the Am.Soc.M.E. in charge. Thomas W. Hind, of the Crown Cork and Seal Co., gave an instructive talk on the Harris-Southwerk Two-Cycle Diesel Engine, which he assisted in perfecting. With the aid of lantern slides he clearly showed its adaption to pleasure craft and boats of larger size, and gave among its many lucrative features the low fuel consumption, small upkeep and the simplicity of regulation.

March 8—J. K. Shanahan, Secretary to the President of the Sparrows Point Branch of the Bethlehem Steel Co., gave a lecture on Ore to the Finished Product. Mr. Shanahan illustrated his talk by the use of moving pictures, thus showing in detail steps in the manufacture of steel from the mining of the ore in Cuba to the finished product ready for market. Both the talk and pictures aided greatly in giving the members clear and practical ideas on the methods used in the steel industry.

B. A. SULLIVAN,
Branch Secretary.



MINNESOTA BRANCH ANNOUNCEMENT BLANK

LEHIGH UNIVERSITY

February 23—D. MacIsaacs '17 and W. A. Haupt of the Bethlehem Steel Co. were the speakers at the meeting of the Student Branch of Lehigh University.

Mr. MacIsaacs spoke on Subway Underpinning, describing in detail the different methods and the reasons for underpinning. Mr. Haupt's subject was The Bonus System of the Bethlehem Steel Co. He stated that the cost of work depends upon having proper equipment, systematizing and planning the work and also upon obtaining the coöperation of the men. The last was secured through the bonus system. He explained the different methods of this system and showed how each was beneficial to both men and company.

F. M. PORTER,
Branch Secretary.

LELAND STANFORD Jr. UNIVERSITY

February 7—H. P. Miller, Jr., '17 discussed the Lining of Tunnels with Reinforced Concrete at the meeting of the Stanford University Student Branch. He explained the various types of tunnels required on a hydro-electric development and described in detail the methods employed in lining those of the high-pressure type. The collapsible forms used and the manner in which they are set up in the tunnels was illustrated by means of sketches. He next explained the apparatus used for forcing the concrete into the tunnel through steel pipes under pressure and the procedure in placing and pouring the molds so that the work can proceed without interruptions.

A. L. MORGAN,
Branch Secretary.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February 27—F. L. Fairbanks, Mem.Am.Soc.M.E., described briefly the general layout and features of the apparatus at the Quincy Market Cold Storage and Warehouse Co. The meeting was followed a few days later by a trip through the plant by about fifty men who were conducted by Mr. Fairbanks and other engineers. The visitors were much interested in a 1000-ton vertical ammonia machine designed by Mr. Fairbanks, his description of the troubles he encountered and the resulting new features embraced in the construction proving most interesting and instructive.

EDWARD W. ROUNDS,
Branch Secretary.

UNIVERSITY OF MICHIGAN

March 1—The Branch held a regular monthly meeting, with T. Tobey, Fred Sawin and A. E. Hecker as the speakers. Mr. Tobey's subject was Fuel Oil Testing and he discussed the production of fuel oils from the raw material, the government specifications for purchasing of oil and the advantages of oil over coal as a fuel. In his paper on Alcohol as a Fuel, Mr. Sawin brought out the fact that the raw material was unlimited in supply and spoke of the special design of engines burning alcohol. Mr. Hecker showed the distribution of concrete from the mixer to the forms by the most modern methods in his lecture on The Mechanical Handling of Concrete, which was accompanied by lantern slides.

KARL BINTZ,
Branch Secretary.

UNIVERSITY OF MINNESOTA

The accompanying novel and attractive poster has been designed by one of the members of the Student Branch of the University of Minnesota. The original, which measures 11 in. by 13 in., is to be used by the branch to announce its meetings; notice of these will be inserted in the blank space provided for that purpose.

February 12—An illustrated lecture was given by Mr. Goetzenberger, '14, on Power Driven Machinery. E. F. Jones and A. E. Rosenbloom discussed seminar subjects.

March 11-12—The branch held their annual meeting and were most fortunate in having Dr. Ira N. Hollis, President Am.Soc.M.E., address them. Dr. Hollis gave an extremely interesting talk which defended the profession against the assertion that machines have no emotional appeal, pointing out clearly that one who does not feel such an appeal has not the nature to be inspired by it.

HARRY G. FORTUNE,
Corresponding Secretary.

UNIVERSITY OF NEBRASKA

March 6—J. S. Kelley, a member, gave an interesting lecture on the Manufacture and Use of S. K. & F. Ball Bearings. Mr. Kelley illustrated his talk with slides secured through the Society by courtesy of the company.

ORLO A. POWELL,
Branch Secretary.

NEW YORK UNIVERSITY

Instead of the regular meetings in March two inspection trips were made by the Student Branch of New York University. The first to the Singer Sewing Machine Company's plant at Elizabethport, N. J., where the conveyor or continuous system ot casting sewing machine frames was of especial interest; the other to the De La Vergne Machine Company's plant in New York where the blast furnaces, drop forging department, automatic cam cutting machines and the rolling mill and work on the testing floor proved both interesting and instructive.

Joseph Gilman,
Branch Secretary.

OHIO STATE UNIVERSITY

February 15—The Student Branch of the Ohio State University held the first meeting for the second semester, when the following officers were elected: chairman, R. H. Wasson; vice-chairman, S. W. Bowser; secretary, F. E. Smyser; treasurer, R. R. Brown, and sergeant-at-arms, W. G. Owens.

March 7—H. W. Mowery, Mem.Am.Soc.M.E., and Mr. Morgan, Safety Expert of the Norton Mfg. Co., were the speakers at this meeting.

Mr. Mowery, who is connected with the American Abrasive Metals Co., spoke on Slipping Hazards, illustrating various slipping surfaces such as poorly constructed steps and other conditions in industrial life which are the cause of many accidents. The speaker stated that the companies taking precautionary measures to prevent such accidents were not only preventing them but were saving money in so doing; the application of the product which his company manufactures was also shown. Mr. Morgan followed with some general ideas on safety work describing how his company has saved money by the prevention of accidents.

March 8—An interesting paper on The Werkspoor Diesel Oil Engines was read by Mr. Rehn, a member of the senior class.

March 13—A large meeting was addressed by Ira N. Hollis, President Am.Soc.M.E., on Armed Neutrality of the United States and Will It Lead to War. Dr. Hollis explained the position of the engineer, who is the fundamental cause of all history and the basis of all civilization; he said that the real issue of this war is citizenship and the result shall be the life and triumph of democracy.

F. E. Smyser,
Branch Secretary.

OREGON STATE AGRICULTURAL COLLEGE

March 11—The Use of Powdered Coal as a Fuel was the subject of a paper by Mr. Thorne. Plans for future meetings were discussed and the committee reported on the new constitution.

Archer O. Leach,
Branch Secretary.

PENNSYLVANIA STATE COLLEGE

February 8—The Pennsylvania State College Student Branch held a regular meeting, when C. W. Holmberg '17 discussed Surface Resistence of Materials. This was followed by a description of the boiler test recently made by the senior mechanical students at Harrisburg.

At a meeting of the student branches of the various engineering societies, R. L. Sackett, Dean of the School of Engineering, and Arthur Holmes, Dean of the General Faculty, told of the proposed plan to publish an engineering paper in which each department of the School of Engineering will coöperate.

James A. Mease, Mem.Am.Soc.M.E., has resigned as Associate Professor of Machine Design at the College to take up other work. Practically every member of the Student Branch attended the farewell dinner tendered Professor Mease to express their sincere regrets at the loss of his active interest in the Student Branch, and to wish him every success in his new work.

Robert R. Rinkenbach,
Branch Secretary.

UNIVERSITY OF PITTSBURGH

March 8—The first meeting of the Branch was held on Thursday, March 8. Thomas Preston read a paper on Protective Coatings for Steel to Prevent Corrosion, which was followed by prepared discussions by W. Thomas and F. Wachter.

F. C. Noss,
Corresponding Secretary.

POLYTECHNIC INSTITUTE OF BROOKLYN

March 3—The Student Branch of the Polytechnic Institute of Brooklyn held a meeting, with B. Postman '17 as the speaker.

Mr. Postman illustrated his talk on Coal Gas Manufacture and Purification with cuts and diagrams. He gave a brief history of the first application of coal gas to useful purposes, going through all stages of the manufacture and purifying of the gas, clearly describing the apparatus used in each step.

George Cherr,
Branch Secretary.

PURDUE UNIVERSITY

February 20—W. T. Miller, Purdue '16, efficiency engineer with the Lafayette Boxboard Plant, spoke on the process of boxboard manufacture, at the meeting of the Student Branch of Purdue University. Mr. Miller spoke also of the efficiency work which has been carried out by this company which proved of much interest as this plant has been tested many times in the past by members of the faculty and of the student body and as a result has been equipped with all sorts of testing apparatus. Another result has been the increased efficiency of the power plant, which was originally designed for a 40 ton plant, to such a point that the present output is 102 tons per day. This was accomplished without any increase in the power equipment other than the addition of an economizer. Further tests on this plant will be made by the senior mechanical engineers under the direction of three of their body who will base their thesis upon it.

February 27—E. F. Hamilton, Purdue '14, with The Development of Radio Telegraphic Communication as his subject first gave a résumé of the history of the development of radio telegraphy, and then by means of formulae and diagrams brought out some of the more simple of its principles. His explanations were made more understandable by reference to actual pieces of apparatus which had been set up and connected to the University aerial. At the end of the meeting messages were intercepted from several stations, the sounds being heard by the audience through a megaphone to which a loud speaking telephone receiver was attached.

W. G. Schutt,
Branch Secretary.

RENSSELAER POLYTECHNIC ISTITUTE

March 5—Dr. Ira N. Hollis, Pres., Am.Soc. M.E., addressed the Student Branch and students of Rensselaer Polytechnic Institute. The Engineer and the National Crisis was the subject of his talk, which was both interesting and instructive, as it brought before the audience the important role the engineer may play in serving his country.

Eugene E. Harris,
Branch President.

VIRGINIA POLYTECHNIC INSTITUTE

March 10—A. H. Cox spoke on The Steam Turbine vs. the Steam Engine. He described the development of the engine and turbine, the natural applications and efficiency of each and the various types of turbines.

G. F. Minor,
Branch Secretary.

WASHINGTON UNIVERSITY

March 13—Training Workmen was the subject of a talk by Prof. Franz A. Berger, Mem.Am.Soc.M.E., at the meeting of the Student Branch of Washington University.

Professor Berger spoke in particular of vocational training and its development in foreign countries, illustrating his remarks with photographic views of the different shops and plants in general. He described one plant employing a very large force and building a

great variety of machines, explaining in detail their system of apprenticeship and training.

WALTER H. KUTZ,
Branch Secretary.

UNIVERSITY OF WISCONSIN

January 11—Prof. G. L. Larson, Mem.Am.Soc.M.E., addressed the Branch on the benefits which could be gained from the organization. He also pointed out the advantages accruing from membership in the national society, to which the Student Branch is a stepping stone.

February 15—The election of officers for the following semester was the purpose of the meeting. The new officers are: President, Asher E. Kelty; vice-president, J. Frank Roberts; secretary, John M. Wood and treasurer, Arthur O. Bushholtz. On March 1 the members participated in a theatre trip.

March 11—Before a large audience, the past work of the Branch was reviewed by the president and new plans outlined; following this Prof. C. I. Corp, Mem.Am.Soc.M.E., and Prof. G. L. Larson, Mem.Am.Soc.M.E., incoming and outgoing Honorary Chairmen respectively, addressed the members.

Professor Corp pointed out the benefits to be gained by membership in the Branch, gave suggestions for coming meetings, emphasized the need for training in public speaking, and advocated Junior membership in the Society at the earliest date possible. It was also announced that Calvin W. Rice, Sec. Am.Soc.M.E., would shortly visit the Branch.

JOHN M. WOOD,
Branch Secretary.

WORCESTER POLYTECHNIC INSTITUTE

March 2—Victor W. Kliesrath, Mem.Am.Soc.M.E., gave an address on Modern Ignition Systems. Mr. Kleisrath divided his talk into two parts: in the first he gave a résumé of the progress of engineers along the subject of ignition systems, and in the second he brought home his points very effectively by means of lantern slides.

He described the spring type of magneto which the company first manufactured, taking his listeners step by step to the high-tension rotary magneto, then describing the new field opened up by the advent of the Dual and Duplex systems of ignition. Aided by the valuable apparatus which he had with him the speaker was able to demonstrate each type of which he spoke. At the close, Mr. Kliesrath exhibited a newly designed and built magneto for use on 12-cylinder engines, which will not appear upon the public market for several months.

H. P. FAIRFIELD,
Branch Secretary.

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 15th of the month.

MECHANICAL ENGINEER, single, with experience in petroleum refining and training in Europe, for work in Mexico. State experience and education. 543.

ENGINEERS to train and develop in fundamentals of firm primarily engaged in distillation of coal tar, with resultant principal production of bituminous road and roofing materials. Ultimate object, filling operating positions in various plants as foremen, head chemist, assistant superintendents, or superintendents. Preferably men with chemical-engineering training. As contemplated work will eventually be executive, ability to handle men is desirable asset. 796.

DESIGNERS and SPECIAL ENGINEERS. High-grade technical engineers for heavy machine-tool and press designing; high-grade engineers capable of working out problems and designing conveying machinery for handling heavy material between machines; engineers to work out automatic press feeds, and layout draftsmen as assistants to head designers. Location Wisconsin. 871.

SALES ENGINEER, man 25 to 28, couple of years out of college. 879.

DRAFTSMAN who would invest some money in a prosperous shop and is familiar with horizontal return-tubular boilers and boiler-shop work in general. State age, experience and salary desired. Location New Jersey. 881.

DRAFTSMAN, first class, experienced in Corliss engines and heavy machinery for shop in Southern Ohio. Give all particulars in first letter. 888.

STRUCTURAL STEEL DRAFTSMAN. Salary depends on man. 889.

MACHINERY DESIGNER in steam-turbine department. Location Massachusetts. 894.

MECHANICAL or ELECTRICAL ENGINEERS, at least three years' training in technical school of standing, and one year's experience in some branch of electrical industry. Salary $90 per month. Location New York. 895.

OFFICE and FACTORY MAN with general experience. Must be qualified to investigate conditions of any department, report to office manager, and make suggestions of value. Salary to start, $20 to $25 per week. Location Connecticut. 896.

YOUNG ENGINEER on special-plant operation and investigation work in development of oil burners. Location Minnesota. 899.

MECHANICAL ENGINEER, 25 to 30, experienced in power pumps, power working heads as used in agricultural districts and pneumatic water-supply systems of various kinds installed to supply water for domestic use where waterworks are not otherwise available. Experience in design and construction desirable. Location Iowa. 900.

SALES ENGINEER. Technical knowledge of steam turbines, centrifugal pumps, fans and blowers essential. Selling experience desirable. Prefer college man under 30, with several years' practical operating experience and some sales work. First letter must contain complete record together with minimum salary. Location Pittsburgh. 903.

TRACER for drawings and blueprints and detail work in connection with engineering office. Location Pennsylvania. 905.

MASTER MECHANIC for lead-smelting plant, operating blast furnaces and concentrating mills; must be man of strong personality, capable of handling varied classes of mechanics. Give full details of education and experience. Location Utah. 906.

COMBUSTION ENGINEER, experienced in power-plant and stoker operation. Familiar with modern instruments. Location Philadelphia. 907.

ASSISTANT in setting premium wage rates in Ohio plant, manufacturing gas tractors. Young man who has had machine-shop experience. Excellent opportunity in line of work which is not crowded. College man preferred. 908.

SUPERINTENDENT of steel foundry. Strictly confidential. Eastern location. 909.

ASSISTANT to head of experimental department. Location New England. 911.

MECHANIC, high-grade, experienced in erecting machinery. Location Philadelphia. 913.

YOUNG ENGINEER to train in sales work in territory around New York and New England. Good personality and some commercial training. Salary $75 to $120 a month. 914.

DRAFTSMAN for same company as 901, accustomed to machine-design, ventilating and heating work, to train in. Salary $18 a week to start. Location New York. 915.

SALES ENGINEERS to take charge of territory in Cincinnati, Indianapolis, Chicago, Detroit districts, or work can be handled by men working some other line. 916.

DRAFTSMAN for engineering department of New Jersey plant, with engineering education and experience; laying out and installation of new machinery in various departments of plant, providing for drives, foundations, etc., making drawings and plans for changes and improvements in equipment, and location, which include roofing, machinery, fire and steam stills for manufacture of asphalt, power equipment, crushing and conveying machinery. Salary $175 per month. 918.

STEAM EFFICIENCY ENGINEER for New York concern. Man thoroughly qualified, with operating experience and theoretical training. Duties involve traveling, principally examination of large steam-turbine plants, analysis of operation and introduction of improvements and economies. Position responsible and important. Salary adequate. Tact a requisite. Replies should give full record of qualifications and experience and should state salary. 921.

ASSISTANT CIVIL ENGINEER, CORPS OF CIVIL ENGINEERS U. S. NAVY. Examination will be held at the Navy Department, Washington, D. C. Address the Chief of Bureau of Yards and Docks, Navy Department, Washington, D. C. 924.

THREE DRAFTSMEN, pipe work, covering steam, hydraulic water, and air piping. Also machine designers and plant-layout men. Also first-class structural-steel and power-plant man. Location Ohio. 927.

DRAFTSMAN familiar with valve detail and design and with experience on estimating and layout work. Excellent opportunity for competent man. State age, experience in detail, references and salary expected. Apply by letter. Location New York State. 928.

HIGH-GRADE DESIGNER on hydraulic machinery. Permanent position. Must be reliable and have capacity for work. State age, nationality, experience, and salary expected. Location Michigan. 929.

ASSISTANT ENGINEERS, one to be responsible for the layout and installation of mechanical equipment in connection with power plants and industrial-building design; the other, a man who can take the responsibility of complete design on industrial buildings and write specifications. Positions pay $2,000 a year. Location Connecticut. 930.

ASSISTANT TO PURCHASING AGENT, to take care of engineering specifications and contracts and act as consulting engineer; position calls for general experience in mechanical engineering and in all matters relating to construction. Location New York State. 932.

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 15th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

RAILWAY MECHANICAL ENGINEER, at present employed, age 37, technical education. Seventeen years' experience as railway machinist, draftsman, chief draftsman and mechanical engineer. Desires position with railway company, railway supply house or industrial plant, with greater responsibility and opportunity. Location immaterial. Salary $2400. D-118.

FUEL TESTING ENGINEER. Graduate, age 34. Seven and half years' experience in scientific testing of coal in industrial plants, for large coal company in Middle West. Desires position as combustion engineer for large user of coal. At present employed. D-119.

SALES ENGINEER. Graduate, experienced in scientific testing and selling of coal. Desires position as sales manager for coal-operating company. At present employed. D-120.

SUPERINTENDENT OF MACHINE SHOP or MASTER MECHANIC. Graduate M. E. High-grade tool designer and expert in standardization of product. Good organizer and executive, with 18 years' practical experience in manufacture of high-grade machinery and precision tools. Salary $3600. D-121.

RESPONSIBLE POSITION with manufacturing or consulting engineering firm or with a high-grade school of technology desired by mechanical engineer with ten years' experience in machine shops and engine works. Fifteen years as head of a well-known engineering school. East preferred. D-122.

MECHANICAL AND DIESEL-ENGINE ENGINEER, with practical and theoretical experiences, who held successfully executive positions in design and manufacture of, and experimenting on marine and stationary Diesels in Europe and in America, desires to associate with engineering concern contemplating building Diesels, or already producing oil engines. Best references of ability, business knowledge, etc. D-123.

INDUSTRIAL ENGINEER. Technical graduate, age 29. Three years' experience as designing draftsman of industrial plants, transmission machinery and labor-saving devices. Past two years on industrial-engineering staff; experienced in time study, scheduling, planning, modern cost system, etc. Ability to increase production and decrease costs, standardize equipment and improve method of manufacture. At present employed but desires change. D-124.

WORKS MANAGER wishes to make change. Has had more than twenty years' experience, having for the past fifteen years held position as factory or production manager in plants employing from 800 to 1500 men. At present employed. D-125.

MECHANICAL ENGINEER. Technical graduate. Over 20 years' mechanical and executive experience. Now employed. Desires to locate with large manufacturing concern as chief engineer. None but high-class executive position will be considered, where waste and patronage do not prevail but efficient plant operation is demanded. D-126.

ASSISTANT MANAGER or SUPERINTENDENT. Will consider position as chief engineer or resident engineer. Location immaterial. D-127.

DIRECTOR or PRINCIPAL of trade or vocational school. At present director of trade school. Technical education. Twenty years' practical experience in machine work and teaching. Best references. Desires to make change. D-128.

CHIEF ENGINEER. Age 35. Desires position of responsibility with live company, as head of engineering department. Successful in designing with view of low-cost quantity production, interchangeability, etc. Has held present position eight years, in charge of engineering department and drafting office with large corporation in Middle West. Desires to locate where ability counts and greater opportunity for advancement exists. Salary $250 to $300 per month. D-129.

EXECUTIVE ENGINEER. Age 30. University of Wisconsin M. E. graduate. Seven years' experience in industrial plants and consulting engineering, embracing power-plant design and testing; specifications; reports; efficiency in power generation and utilization. Employed at present, but desires change to position with better prospects. Location preferred, Middle West. D-130.

YALE GRADUATE mechanical engineer. Six years' practical experience. Desires to change his position for one with either manufacturing company or consulting engineer. D-131.

SPECIALIST in design of boiler furnaces and boiler-room equipment. Mechanical engineer. Age 42. Twenty years' experience in power-plant design, construction and operation. Would take charge of power-plant-construction work; now superintendent of large power station. Present salary $3,000. D-132.

MECHANICAL ENGINEER. University graduate. Age 34. Ten years' experience in West on contract work, design and superintending construction of industrial plants and varied projects; operation and plant efficiency; plans, estimates and reports, design of special machinery. Now in charge of mechanical and civil engineering work for Western concern, but desires to make new connections. D-133.

STUDENT MEMBER. Bucknell University; graduate '17 in mechanical-engineering course. Three years' practical shopwork;

two years applied shopwork; assistant instructor in mechanical drafting for two years. D-134.

MECHANICAL AND ELECTRICAL ENGINEER. Graduate University of Illinois, age 31, single, I. C. S. Spanish. Ten years' experience erecting and operating power plants. Three years in present position as superintendent of large public utility. Desires position as chief engineer or plant manager, or will travel. Can produce results in economical operation of any power plant. Has $500.00 worth of measuring and recording instruments. Will go anywhere. D-135.

GENERAL MANAGER or MANUFACTURING EXECUTIVE. Age 43. At present employed. Twenty-two years in various executive capacities, progressively from small-shop foremanship to vice-presidency, in charge of engineering and manufacturing in large establishments. Experience broad and general, covering foundry and machine-shop work, large and small, and including engines, turbines, blowers, centrifugal pumps, condensers, miscellaneous machine shop products, interchangeable parts, tools, jigs, gages, etc. Knows men and how to handle them. Expert in cost accounting and control. Has done considerable selling, traveled extensively at home and abroad. Capable full charge of large plant. Satisfactory reason for desiring change. Highest references. Available thirty days. Location Philadelphia or vicinity. D-136.

MECHANICAL ENGINEER. Technical graduate, age 39. Twenty years' experience in shop and office on small intricate work, such as guns, type-setting machinery, typewriters, adding machines, and cash registers. D-137.

MANAGING EXECUTIVE. Age 37. Fifteen years' experience in mining, quarrying, and manufacture of gypsum and gypsum products, as purchasing agent, designer, and operating manager. Thoroughly familiar with the business in all branches, especially organization and development of efficient machinery and working forces and value of costs and their application to manufacturing. Desires responsible position with financially responsible concern in same or similar business, in which interest may be attained at later date. Now engaged in consulting work; free for appointment after April 1. D-138.

ENGINEER. Technical graduate, twelve years' engineering and manufacturing experience, combined with business and sales. Opportunity desired where technical training and with good business judgment will be of value. D-139.

FACTORY MANAGER or PRODUCTION MANAGER. Technical graduate, 31, ten years' experience in costs, efficiency engineering and factory reorganization and management. Trained in stopping leaks and increasing output. Reference to several concerns as to ability and results secured. D-140.

COMBUSTION ENGINEER. Age 30, married, technical graduate. Four years' experience in boiler-efficiency work, thoroughly familiar with hand and stoker-firing methods and handling boiler-room labor; anthracite or bituminous coal; former assistant smoke inspector of large city. Experienced in fuel analysis, furnace design and other essentials of boiler-room practice. Location preferred, 100 miles from Philadelphia. D-141.

MECHANICAL ENGINEER. Technical graduate, age 35. Eight years' practical experience in design, construction, erection, testing and maintenance of power-generating and distributing equipment. Fully competent to handle problems in station-betterment work. Can qualify as inspector of apparatus under construction. Has had A1 experience on boilers, turbines, steam, oil and gas engines, condensers and electrical equipment. Aggressive, resourceful and capable. Can furnish best references. At present employed as estimator and sales engineer, but desires larger field of action. Available on short notice. Location immaterial. D-142.

CHIEF ENGINEER. Graduate M.E. Age 35. Now construction and maintenance engineer in charge of construction, maintenance and power departments of large electrically driven dye plant; wide experience in construction and maintenance along both electrical and mechanical lines. Seven years chief engineer Western sugar factory. Four years erecting engineer for manufacturer of large steam turbines. Minimum salary $2750. D-143.

GRADUATE ENGINEER. Will graduate from mechanical engineering in June; two years' practical experience in machine-shop work, some experience in turbine design. Will accept any good position offering advancement. References available. D-144.

WORKS MANAGER or ASSISTANT TO EXECUTIVE. Mechanical engineer, age 37. Technical graduate. Fourteen years' varied experience in design, construction, and installation work, including ordnance, ballistic apparatus, hydraulic machinery and structural steel. Well grounded in the fundamentals of steam and electrical engineering. Thoroughly practical, with executive ability, and not afraid of work or responsibility. Location preferably East or South. D-145.

ASSISTANT PROFESSOR or INSTRUCTOR, if there are possibilities of advancement, in mechanical engineering. Degrees of E.E., M.E. and Sc.D. Six years' teaching experience in two of the leading technical schools and some in power plant work. Will be open for engagement after June 15. Location in or near New York preferred. D-146.

ASSISTANT SUPERINTENDENT, age 25, M. I. T. graduate. Experienced in woodworking and in the design of package conveyors. At present employed. Location preferred, New England. D-147.

MECHANICAL ENGINEER, age 31, married. Technical and practical shop work. Wide experience in testing of materials and equipment for large modern factory. Seven years' work on the designing, testing and installation of valves, fittings and steam specialties. Competent in getting out concise reports and business correspondence. Desires position where ambition and hard work are prime necessities. D-148.

WORKS ENGINEER or ASSISTANT WORKS ENGINEER. Mechanical engineer married, age 32. Graduated from prominent engineering school. Three years' experience in operation, erection and maintenance of large boilers, steam engines, gas engines, piping systems and small steam turbines. Three years' experience teaching mechanical, steam and gas engineering practice. Resourceful, tactful and can handle men. Will start at $2000 per year if with good concern, and there is opportunity for advancement and responsibility. Available July 1. D-149.

MECHANICAL ENGINEER with experience in the design and manufacture of aeroplane motors, also expert tool designer, desires executive position in connection with engineering department. Now employed. Location immaterial. D-150.

TECHNICAL GRADUATE, age 31, experienced as a general machinist in locomotive repairs, gasoline-engine construction, foreman in the motive-power department of a leading railway, draftsman in the manufacture of brass goods, pressure regulators and tools connected with the same, and, in the factory system connected with the latter position, desires to locate with a going concern in the industrial field with aim of developing into a position of responsibility. Other conditions considered. Prefers medium-sized cities of Middle West. D-151.

COMBUSTION ENGINEER, age 34, technical and practical. Ten years' experience in combustion and boiler-house efficiency. Familiar with large and small boiler-house practice, different types of boilers and stokers. At present employed by large concern, having produced their best results. Desires a change. Would like to connect with firm having large boiler house or chain of boiler houses requiring the services of a progressive man. Highest references. D-152.

MECHANICAL ENGINEER. Technical graduate with ten years' experience as draftsman and superintendent of construction desires position where his four years' railroad shop training and knowledge of works management will be of value. D-153.

MECHANICAL ENGINEER, age 25, technical graduate. Has machine-shop and drafting experience, knowledge of accounts and up-to-date efficiency methods. Desires position as assistant to executive or works manager. Successful experience as executive. Now employed. D-154.

POWER ENGINEER or FACTORY MAINTENANCE ENGINEER. Technical education and six years' experience in gas, oil, and steam plants, light, heat and power transmission, factory upkeep and extensions. At present employed. D-155.

ASSISTANT PROFESSOR in mechanical engineering or electrical engineering or similar position as supervising technical instructor. Graduate M.E. from one of the leading engineering universities. Eight years' experience in teaching engineering subjects. D-156.

MANAGER, ASSISTANT, SUPERINTENDENT, EXECUTIVE or SALES ENGINEER. Technical graduate in mechanical engineering; varied experience in mechanical, electrical, and civil engineering lines, involving design, inspection, reports, responsible charge of construction work, plant operation, management, purchasing, etc., in connection with power, lighting, and industrial plants, electric railways, etc. Salary $3,000-$3,600.—D-157.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY

One of the most significant movements brought about by the European War is an intensification of scientific and engineering research. The reasons for this are fairly obvious. In the first place, it is due to the effort to satisfy the tremendous demand for war materials and necessities of life, where the supply of the latter has been interrupted. In the second place, the search for new ways and means of production is caused partly by the desire to make the country independent of foreign supply of basic essentials of manufacture; and further, it expresses the effort to pay the cost of the present struggle by a production increased in volume and more economical in method.

In the present issue, this tendency is exemplified by the article of Le Chatelier on Scientific Problems Awaiting Solution.

THIS MONTH'S ARTICLES

In the section Aeronautics attention is called to a description of sand-load tests on wings of a Curtiss flying boat.

Data on the structure of the coating of tinned sheet copper, in relation to a curious case of corrosion of this material, are reported from a Technologic Paper of the Bureau of Standards, of which an advance abstract has been courteously supplied to The Journal by the Bureau.

At Queens University, Kingston, Ontario, an investigation on cobalt alloys with non-corrosive properties has been carried out.

Also from an advance publication of the Bureau of Standards is reported a description of a specific-gravity balance for gases.

The limits of inflammability of gaseous mixtures form the subject of an investigation by Prof. W. M. Thornton, abstracted from the (British) *Philosophical Magazine*.

The engineering phases of smoke abatement are discussed by Osborne Monnett, who considers draft as by far the most important factor in the question of reducing smoke effectively.

An editorial in a British publication, *The Auto*, reports a discussion at the Midland Institute of Mining Engineers, Birmingham, England, on the use of benzol as a fuel in Great Britain after the War. The discussion is of particular interest because it covers the question of distribution as well as the more strictly technical features of use.

In the section Hydraulics will be found a description of a California water-power installation, claimed to constitute a record for low-head development. Its turbines are so designed as to handle hydraulic heads of but 8 ft. In this description particular attention is called to the design of the sliding-jaw clutches and the oil-pressure governor.

From the *Cornell Civil Engineer* is briefly abstracted a paper, by G. C. Brown, entitled Some Notes on Stream Flow. In addition to the information reported in the abstract, the paper contains highly interesting passages which could not be reported on account of lack of space.

Experiments carried out at Purdue University on carburetor performance have been reported by Prof. R. C. Berry in a paper before the Society of Automobile Engineers. They present coördinated data on the performance of the carburetor proper, apart from that of the engine, and show clearly the variation of output and efficiency of the engine as functions of fuel consumption.

A novel type of combustion engine invented in this country by R. M. Hvid is described by E. D. Blakely. While it works essentially on the same principle as the Diesel engine, its cycle is rather different from the latter.

The Railroad Engineering section contains three articles of interest. The question of superheat in locomotives is treated in an abstract of the discussion at the last convention of the American Railway Master Mechanics' Association.

A description of the application of Mogul running gear and machinery to a Mikado locomotive is taken in abstract from the *Railway Mechanical Engineer*.

From a paper by George L. Fowler are abstracted some data on water conditions in the locomotive boiler which indicate how little one can depend on the analysis of the raw water when it is desired to determine the conditions prevailing in the boiler.

The section Steam Engineering contains two articles devoted to an essentially similar subject, viz., power generation on a very large scale. Thomas Wilson describes the Ford boiler plant with its seven immense boilers. The editorial article in another issue of *Power,* devoted to the description of the Buffalo General Electric Company, presents data on an enormous installation plant for 200,000 kw. capacity, in units of 30,000 to 35,000 kw., using pressures and superheats which a few years ago would have been deemed practically impossible.

Aeronautics

Sand-Load Tests on Wings of Curtiss Flying Boat H-12, John H. DeKlyn and G. E. Hawthorn

The tests described here were conducted at the order of and according to the standard instructions of the British Admiralty. The wing was the largest ever tested in this country, the overall span being 92 ft. The wing on but one side of the boat was tested.

The loading required is given by the formula:

$$P = N(W + W_1 - W_2) - W_2$$

in which P = weight of sand on wing surface; N = required factor of safety; W = net weight of machine; W_1 = useful load carried, including gasoline, pilot, passenger, and any other useful load; and W_2 = weight of wings. The total load applied was 28,110 lb., of which the upper plane carried 69 per cent, or 19,400 lb.; and the lower plane 31 per cent, or 8700 lb.

As a result of the test (fully described in the original article) it was found that the wing withstood the load specified by the Admiralty instruction without permanent deflection or signs of failure.

An illustration of the strength of the wings is afforded by the fact that the wing was tested with a load of sixty people, amounting to 9930 lb., which is, however, only about half the maximum load. (*Aviation and Aeronautical Engineering,* vol. 2, no. 3, March 1, 1917, pp. 136-137, 2 figs. *e*)

Note on Stresses in Built-up Rectangular Bodies Due to Rudder Forces, Alexander Klemin and W. B. Ford

The article discusses the stresses in a body produced by a rudder when its center of pressure is fairly high above the center line of the body. In this case the wire and longeron stresses induced by the forces of the rudder are worked out for a single panel of a typical rectangular body, assuming the stabilizer to be 35 sq. ft., the elevator 11 sq. ft., the rudder 8 sq. ft., and the vertical fin 45 sq. ft., in area.

The rudder forces produce, first, bending in a vertical plane through the middle of the aeroplane; and second, twisting about the axis passing through the centers of the transverse diagonal wires in any panel. To allow for bending, it is sufficient to divide the rudder load equally between the upper and lower planes of the body, and to draw stress diagrams in these planes in the usual manner. A process is indicated to allow for twisting.

The article presents complete computations for one panel of a body under rather severe air-load conditions; these computations including also the landing stresses. The data are presented in the form of a table, showing, among other things, that the effect of the rudder loads is by no means negligible; while the air loading assumed (speed 100 miles per hour; rudder of 7 sq. ft. area, turned at 20 deg. simultaneously with stabilizer at—6 deg. and elevator at—20 deg.) is rather severe, it may well occur after a steep dive. In such an event the factor of safety would be considerably smaller than that which would follow from the ordinary calculations under Army specifications. Incidentally, it is shown that the stresses due to landing are sometimes of lower and sometimes of greater value than those obtained from the combined air loads, showing the advisability of carrying through both air- and landing-stress calculations. (*Aviation and Aeronautical Engineering,* vol. 2, no. 3, March 1, 1917, pp. 142-143, 4 figs. *t*)

Engineering Materials

The Structure of the Coating on Tinned Sheet Copper in Relation to a Curious Case of Corrosion of This Material, Paul D. Merica

The attention of the author has been directed to a curious and instructive case of local corrosion or pitting in tinned sheet-copper roofing. The pits occur in general along the line of surface scratches, having appeared some eight or ten years after completion of the roof. These pits are apparently unrelated to the service conditions and to the direction of rolling of the sheet.

A study of the structure of tin coating on copper has been made, and has shown that this coating consists of at least three layers, viz., a thin layer of Cu_3Sn immediately next to the copper, then a layer of Heycock and Neville's constituent N, containing about 60 per cent by weight of tin, and, finally, a layer of the eutectic of tin and copper, in which is found most probably also the lead when it is present in the tinning mixture. This coating in the case of the corroded sheet was thin, averaging about 0.012 mm. in thickness, and quite variable in both thickness and structure, varying from 0.006 mm. to 0.03 mm. in thickness. At many points there were breaks in the continuity of the alloy layer; at others, breaks in the continuity of the eutectic layer.

Etching experiments and measurements of electrolytic e.m.f. of these layers towards various solutions, such as water, dilute acids, and acids to which ferric or stannous chlorides had been added, showed that the constituents of these intermediate alloy layers are more electronegative, i.e., less corrodible than either the tin or the copper. Values were found for the e.m.f. of these alloy constituents against copper in various solutions varying from — 5 to — 80 millivolts.

When the copper becomes exposed, therefore, as in the present case at the bottom of the scratches on the surface, it forms together with the alloy layer a galvanic couple, electrolytic action sets in, and the copper at these points is corroded, forming the pits described.

Many instances are known, of course, of roofs of such material which have been in service for twenty or more years, under severer conditions as regards soot, smoke, etc., than were those under which the roofing in question failed, and which nevertheless have not shown signs of such pitting. Explanation of this variation in service rendered by different samples of the same type of roofing material must be sought in the variation of mechanical abuse, such as scratching, which it receives, and also in the uniformity of structure and thickness of the tin coating. (Abstract of *Technologic Paper No. 90,* Bureau of Standards, Washington, D. C., July 11, 1916.)

Cobalt Alloys with Non-Corrosive Properties, Herbert T. Kalmus and K. B. Blake

Data of an investigation conducted at Queens University, Kingston, Ontario, for the Mines Branch of the Department of Mines, Ottawa, with a view to determining the use of cobalt as an inhibitant of corrosion.

The main purpose of the present investigation was to determine the effect of the addition of small quantities of cobalt on the atmospheric corrosion of iron and mild steel—in particular, very pure iron prepared by the open-hearth method for sheet roofing material.

The comparative effects of small amounts of cobalt, nickel, and copper were studied.

The experiments cannot be considered as conclusive, partly because of the methods used and also because no heat treatment was given to the alloys. But from these premiminary experiments it appears that additions of small percentages of either cobalt or nickel to very pure ingot iron add to its non-corrosive properties. When used in like amounts, cobalt seems to be more effective than nickel.

It was also found that the rust on the cobalt samples is more tenacious than that on the other samples, and particularly that it is of a much darker color and is removed by mechanical means with very much greater difficulty than the rust formed on very pure ingot iron containing no cobalt. In this connection it has also been found that annealed samples differ from unannealed in that for the annealed samples the rust is light in color and much more readily removed than in the case of unannealed ones.

In addition to ordinary corrosion tests with long exposure, a few accelerated corrosion tests were made on some of these alloys. These tests, which must be considered as only preliminary, would indicate that the addition of monel metal to American Rolling Mill Company ingot iron to the extent of about one per cent produces a more non-corrosive alloy for sheet roofing materials than the addition of similar small percentages of cobalt.

It has also been found that the addition of copper to American ingot iron to an extent between 0.25 and 0.75 per cent seems to be conducive to reducing the corrosion of this quality of iron under atmospheric conditions. It is difficult to say, however, whether or not the addition of copper in these amounts has a greater or less effect than the corresponding amounts of nickel or cobalt. (*Researches on Cobalt and Cobalt Alloys* conducted at Queens University, Kingston, Ontario, for the Mines Branch of the Department of Mines, Part IV Canada Department of Mines, Mines Branch, Ottawa, 1916, 37 pp., illustrated, *e*)

Fuel and Firing

Engineering Phases of Smoke Abatement, Osborne Monnett

The writer states that if he were to answer the question: What are the three most important things in smoke abatement? he would be tempted to say: first, draft; second, *draft;* and third, DRAFT.

In investigating the smoke problem in Chicago, where he was formerly Chief Smoke Inspector, it was found that draft was so important as to overshadow every other consideration; and through a long series of investigations covering some thousand separate and distinct studies of boiler settings, the curve was developed (Fig. 1) which tells how much draft is needed for different rates of combustion. Roughly, the rule is this: We need 0.1 in. draft over the fire per pound of coal burned per square foot of grate surface per hour. That tells the story almost entirely throughout the range of the curve. Beginning with 0.15 in. per sq. ft. over the fire, we are able to burn 15 lb. coal per square foot of grate surface per hour smokelessly. Cases can be cited where more was burned, but not smokelessly.

The limit rate of successful smokeless combustion for hand-fired units is about 28 lb. coal per square foot of grate surface per hour.

The rate of combustion in any plant is fixed, first, by the load. When the load is known, the ratio of grate surface to heating surface has to be fixed. These two factors decide the rate of combustion, and with these the curve will show how much draft is needed over the fire.

In laying out a stack it is necessary to know how much draft loss there is in the particular type of boiler setting selected, so as to know the proper amount of draft over the fire to be provided. This loss runs from 50 to 65 per cent of the draft available at the stack side of the damper. For

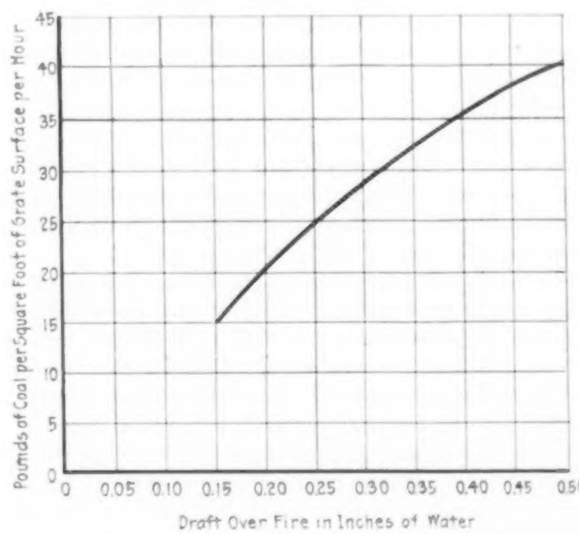


Fig. 1 Draft for Smokeless Combustion

determining the height of stack the author recommends the Stirling formula.

In studying the smoke problem in Chicago, it was realized that it would be necessary to develop some type of hand-fired furnace that could be operated within the smoke limits. After several designs had been tried, they came to flush-front Dutch-oven settings. These settings, however, made more smoke than the standard Hartford setting. The reason for this is supposed to be as follows: When high-volatile coal is thrown on a fire, there is a normal distillation of volatile matter due to the heat of the firebrick. But when you throw coal on a fire with a Dutch oven, there is not only the normal distillation of volatile matter, but in addition an artificial distillation due to the high temperature of the heat radiating from the red-hot firebrick over the fire, resulting in a double distillation of volatile matter. This causes dense smoke in spite of all efforts to prevent it.

By taking off the brickwork over the fire the rate of volatile distillation was reduced, because there was no radiation of heat from the red-hot firebrick. This not only gave a smokeless furnace, but also increased the steaming capacity of the boiler, because there was a direct radiation from the grate into the boiler.

The next problem discussed in the paper is that of burning coal at lower rates of combustion. Here, after a long evolution, we have come to a down-draft boiler with a water-cooled grate, which, if properly handled, is smokeless. (*Proceedings of the Engineers' Society of Western Pennsylvania,* vol. 32, no. 9, December 1916, pp. 772-795, 10 figs. *gp*)

Benzol After the War

The demand for explosives created an enormous increase in the production of benzol in Great Britain. A certain amount of this product and of toluol, which is produced side by side with benzol, will be required for dyes, even after the cessation of hostilities, but a market will have to be found for the excessive production, or approximately forty million gallons of benzol per year.

W. Newton Drew touched upon this question in his paper on The Rectification of Benzol, recently read before the Midland Institute of Mining Engineers, Birmingham, Eng. He expressed the opinion that this excess of benzol will have to be sold as a motor spirit to take the place of gasoline. To make this possible, the benzol must be of standard quality as regards distillation tests, purity and dryness, and must be easily obtained everywhere in convenient form, and at a standard price.

While nothing has been done as yet to prepare for this emergency, the speaker urged that the by-product installations of each district throughout the country should be linked up in some association or associations outside the coal and coke industries.

As regards the advantages and disadvantages of benzol as motor fuel, the President of the Institute, C. C. Ellison, remarked that he was one of the first to use benzol in cars, but had to give it up because of its objectionable smell. Since then, however, improvements in washing it have progressed so far that now a very good spirit is obtainable.

W. Newton Drew pointed out that 90 per cent of benzol contained approximately 84 per cent benzene, 15 per cent toluol, and 1 per cent xylene, and that standard benzol consisted of 96 per cent benzene and 4 per cent toluol. It is important to bear in mind that a small addition of toluol is not only not an adulterant, but has proved of great benefit in that it increases the calorific power of the fuel, and in winter it prevents its freezing. (Editorial in *The Auto,* vol. 22, no. 6/840, February 9, 1917, pp. 92-93, *g*)

Vertical Furnaces

A furnace has been recently completed to a Government order in England by the Monometer Manufacturing Co., Ltd., Birmingham, in which a novel method is used.

The problem was to have several long tubes heated uniformly throughout their length to a red heat, the temperature to be kept constant within small limits. This was effected by supporting the tubes in a vertical position in the furnace and applying automatic heat control. Several rings or series of burners are arranged round the furnace at different heights in order to obtain a uniform distribution of the heat, a muffler or protection tube being interposed between the burners and the tubes to be heated in order to prevent heat from impinging directly upon the inner tubes. By this means the temperature throughout the periphery of the furnace as well as the height of the furnace is made uniform.

One control is provided for each ring or series of burners. The control operates on the thermostatic principle and is adjustable to suit the temperature desired. (*Aeronautics,* vol. 12, no. 170, January 17, 1917, p. 55, 1 fig. *d*)

Gas Engineering

A Specific-Gravity Balance for Gases, Junius David Edwards

The need for an accurate method of determining gas density has been especially urgent in the natural-gas industry, where the measurement of gas by means of orifice meters requires a knowledge of the density of the gas. An investigation by this Bureau of the effusion type of apparatus, which has been generally used for this purpose but which has proven unreliable in practice, has shown the need of more precise methods. To supply this need the present method was adopted and suitable apparatus designed.

The principle of the method employed is based upon the laws of the compressibility (Boyle's Law) and the buoyant effect of gas. The balance contains a beam which carries on one end a relatively large globe and on the other a small counterweight; the beam is enclosed in a gas-tight chamber. The buoyant force exerted upon the globe is proportional to the density of the gas and therefore to its pressure. Therefore, if the buoyant force exerted upon the globe is made the same as shown by its position of equilibrium when it is suspended successively in two different gases, then the densities of the two gases must be the same at these pressures, or the specific gravity is the inverse ratio of the pressures. In operation the balance case is filled with air and the pressure adjusted until the beam balances. It is then filled with gas and the pressure required to secure a balance is determined in the same way.

The apparatus described provided a quick, accurate means of determining gas density. The balance beam is supported on two needle points, which give high sensibility. The needles are easily adjustable and in contrast with the metal or quartz knife edge usually used can be obtained almost anywhere, are inexpensive, and can be replaced as often as necessary. The success obtained in the use of this apparatus is mainly due to the high sensibility afforded by this means of support. It is necessary to remove the beam from the case only when it is desired to transport it. No leveling bottle is necessary in adjusting the gas pressure within the balance, this being accomplished by means of a needle valve which affords precise control. A portable outfit is described which combines lightness of weight, convenience in use, and durability without any great sacrifice in accuracy. No preliminary calibration of the apparatus is necessary. The results obtained with this balance were compared with those obtained by a direct weighing method and it was shown that an accuracy of one or two parts per 1,000 could be obtained quickly and without elaborate precautions. (Abstract of *Technologic Paper No. 89,* Bureau of Standards, Washington, D. C.)

Gas Gate Valve, D. E. Keppelmann

Gate valves depend upon a disk or disks riding into a groove between two seats for their tightness. As a rule, leaks develop either because of accumulation of foreign matter in the valve or through the scoring of its disk or seats by the pressure.

In fact, the groove in the bottom of the valve acts as a constant trap for deposits of foreign matter. If the groove has been filled with foreign matter, however, it becomes finally impossible to lower the disk, which causes leaks.

The valve described in this article does away with this difficulty by eliminating the grooved trap. The opening and closing feature consists of a solid wedge with the port constantly riding on its seats located in the sides of the valve, creating a clean opening through the valve. This makes the valve self-cleaning, for with the valve open it presents a clean surface flush with the body of the valve. Consequently the foreign matter rides through since there is no trap or groove or restriction of any kind for the accumulation of foreign matter, making it possible at all times to close the valve whenever necessary. When the valve is closed the foreign matter will accumulate against the wedge, and simultaneously with the lifting of the wedge this accumulation is immediately cut from the wedge and carried through the valve by the liquid or gaseous substances in the line.

An additional advantage claimed for the new valve is that no by-pass is necessary to equalize the pressure on both sides of the disk before the latter has been raised, for the seats are never exposed to the elements passing through. Hence scoring is impossible and leakage from this source is eliminated. (*The Gas Age*, vol. 39, no. 3, February 1917, pp. 121-123, 6 figs. *d*)

The Limits of Inflammability of Gaseous Mixtures, Prof. W. M. Thornton

The ignition of an inflammable gas mixed with air depends in a variety of ways upon the proportion of oxygen present. With impulsive sparks or condenser discharge the ignition passes through critical stages when the ratios of the number of oxygen atoms to one molecule of gas are whole numbers. The writer shows that the proportions of oxygen in a limiting mixture are in regular systems.

Burgess and Wheeler have shown that in the case of the paraffins the lower limit of inflammability is inversely proportional to the calorific value of the gas. But this is also the case when the number of oxygen atoms in the limiting mixture bears the same proportion in each case to those required for perfect combustion. The present paper is devoted to an examination whether in general the proportion of oxygen in the limiting mixture has any direct relation to that for perfect combustion. The author finds that in the upper-limit mixtures of the paraffins there is twice the volume of inflammable gas there is in the mixture for perfect combustion, and that, further, the ratio of the upper to the lower limits of inflammability should be nearly constant. He points out that while the upper and lower limits of inflammability can be considered as controlled by the heat liberated in the reaction, it is not the heat set free that controls the oxygen that can be present (and so decides the percentage of gas), but the oxygen that controls the heat. Hence inflammation can only occur when certain numerical relations exist between the oxygen and gas molecules. From this the author derives certain data from which may be predicted the limits of inflammability of certain groups of compounds with fair hope of accuracy. (*The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, vol. 33, no. 194, February 1917, pp. 190-196, 1 fig, *et*)

Heating

Relative Economy of Heating by Steam at Different Pressures, A. Bement

Recently in Chicago tests were made to determine the relative cost of heating with steam at atmospheric pressure as against 3 to 5 lb. pressure in modern office-building plants.

In an analysis of the problem a heat requirement of 5000 B.t.u. per hour was taken. On the whole it appears that there is no appreciable difference in cost in heating at different pressures. There is, however, an advantage in higher pressure from the standpoint of first cost of plant because as the pressure is greater the plant may be smaller. This factor, however, has a limited value in practice unless excessive pressures are used. As a matter of fact, any plant designed to work at 5 lb. should have margin enough to work perfectly at atmosphere, and vice versa, so that in the end the cost of heating will be identical in both cases. (*The Heating and Ventilating Magazine*, vol. 14, no. 2, February 1917, pp. 27-29, *ce*)

Hydraulics

A New Record for Low-Head Development, Rudolph W. Van Norden

Description of an unusual water-power installation of great interest in that the turbines are so designed as to handle hydraulic heads of but 8 ft. The installation was built by the labor of the convicts at the State Prison, Folsom, Cal., and it is stated that the work was free from accident. The prison is situated two miles east of Folsom, on the south side of the American River, tributary to the Sacramento, having its source among the high altitudes of the Sierra Nevada range. For about nine months in the year there is sufficient water in the American River to operate the Pacific Gas & Electric Company's plant at the end of the canal line. During the remainder of the year the river's flow dwindles until in most years it will not exceed 100 cu. ft. per sec. With a canal full of water flowing, and the water level above the prison plant at the spillway line, the difference in water level above and below the prison power house is actually 8.5 ft. During the period of low-water flow the tail-water level falls until the difference in head may be as great as 12 ft. In other words, a variation in head on the turbines may be almost as great as 50 per cent of the normal head. It was required to supply a plant which would deliver continuously not less than 400 hp.

A runner design for high specific speed and consequent great water capacity was essential, and one was adopted of 51 in. mean diameter, operating at 100 r.p.m. and having a nominal shaft horsepower of 215 while operating under 8.5 ft. head with a flow of 285 sec-ft. The design of the turbine was such that while the power output increases more than 50 per cent when the head is increased to 12 ft., the efficiency also increases several per cent.

All machinery is driven by induction motors.

The total weight carried by the thrust bearing is 19,000 lb., to which must be added a hydraulic thrust on the runner of 6000 lb., making 25,000 lb. total load. The two vertical steady bearings are oiled from a glass cup having a capacity of 0.6 gal. of lubricating oil. To prevent the oil following the shaft after passing through the bearing, there is provided between the lower end of each bearing and the annular cup a baffle ring which solidly clamps the shaft, thereby deflecting the oil into the cup.

A horizontal jackshaft extends between the vertical shafts of the two turbines and runs at 300 r.p.m. Upon each end of the jackshaft is mounted a rawhide bevel gear driven from the turbine shafts by cast-iron bevel gears having split hubs mounted on the turbine shaft. As it is intended to drive the

jackshaft from either turbine but not from both at one time, there are two sliding-jaw clutches operated by levers which extend above the generator floor. In the design of these jaw clutches, the following problem had to be solved: In throwing out one clutch in order to engage the other, with both turbines running, it must be possible to momentarily engage the idle clutch before disengaging the running clutch. The generators operating in synchronism, there are 36 points of relative position between the two rotors, any one of which may take place when the machines are synchronized. As the bevel gears have a ratio of three to one, there are 36:3 = 12 positions in a jaw clutch when the two halves of the clutch might engage. In order that the incoming clutch may always be in a position to engage, the jaw clutches are built with twelve radial jaws. The object of the jackshaft was to furnish by belt drive the power to drive the exciter, the governor head and the oil pump furnishing oil under pressure to operate the governor.

One oil-pressure governor controls both turbines. It is so

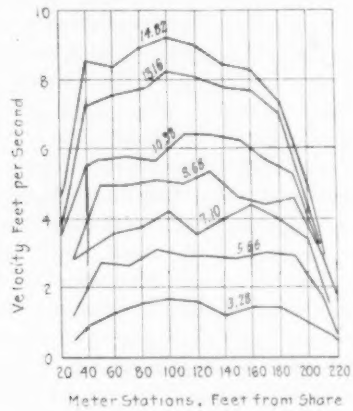


FIG. 2 SURFACE VELOCITIES FOR EACH 20 FT. STATION

arranged that both turbines may be controlled by the governor or one turbine by governor and one by hand, or both by hand. The governor proper stands on the station floor midway between the two generators, the operating cylinder being horizontal and close to the floor. The piston rod of the operating cylinder extends through both heads. Close to either generator and in line with the direction of motion of the governor are the two handwheel mechanisms, which are mounted on a cast-iron frame that carries the crosshead into which the piston rod is fastened; an arm of this frame, which is flush with the floor, carries at its extremity a ball thrust bearing, and passing down through the arm and supported by the thrust bearing is the rotating gate shaft which operates the turbine gates through push-and-pull rods at the lower end of this shaft. Above the thrust bearing and keyed to the gate shaft is a bell crank, and this is operated through two links from the crosshead. The handwheel is on top. Its vertical shaft carries a spur gear which engages a pinion for the purpose of a gear motion reduction. The pinion shaft carries another pinion which engages a rack on the back of the crosshead. The handwheel rigging is contained in a housing integral with the main frame, but is mounted on an eccentric which is moved by a lever fitted with a hand pull. By this means the handwheel mechanism may be thrown out of gear with reference to the crosshead. On the handwheel shaft is a brake operated by a small crank. The piston passes through the crosshead freely, but engages the crosshead by means of a spring bolt operated by a swinging handle. While governing, the spring bolt is in and the handwheel mechanism by means of the eccentric is entirely out of gear. When operating by hand, the pin is pulled out and the eccentric thrown in, and the brake is used to hold the handwheel where desired. The turbine gates are designed to be so balanced as to have an opening tendency up to 0.4 load and a closing tendency above this point. While the gates and mechanism are heavy, one man can handle the gates without difficulty, while the governor moves them easily with an oil pressure as low as 60 lb. (*Journal of Electricity*, vol. 38, no. 3, February 1, 1917, pp. 65-69, 6 figs, *d*)

SOME NOTES ON STREAM FLOW, G. C. BROWN

While taking current-meter readings in the Beaver River at Newport, Pa., a certain measurement was about three-quarters completed when the meter refused to tick off the revolutions. Eight sections had been measured and the stage of the river was such that it was highly desirable to have a reading at that point. Accordingly, the discharges for the eight stations measured were computed for stages just above and below the one under consideration, and also their ratio to the respective total discharges. The results proved to be surprisingly alike, and this prompted a more thorough investigation of the relations that might possibly lie hidden in the field notes gathered from that same stream.

The Beaver River is a stream of no unusual characteristics. A cross-section of the river where the current-meter measure-

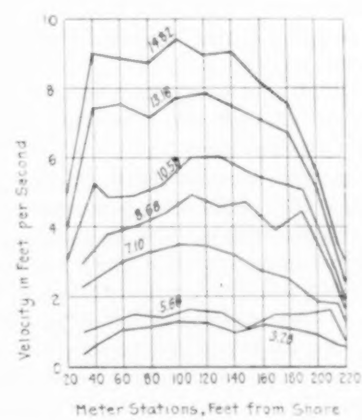


FIG. 3 MEAN VELOCITIES FOR EACH 20 FT. STATION

ments were taken shows a stream with fairly uniform sand and gravel bottom paved with hand-laid rip-rap on one bank and having a natural dirt slope covered with weeds and brush on the other bank.

Gage height 3.28 indicates a very low stage of the river and 14.28 a high flood stage. It might naturally be supposed during this wide variation in height, velocity and discharge that increased cross-current eddies and other disturbances would so confuse the natural line of flow in the stream that no similarity could possibly exist in the curves of low and high stages. It is a surprising fact, however, that marked relations do exist. Fig. 2 shows the surface-velocity curves at each 20-ft. station for different stages. While there are marked variations in some of the curves, there is also a great similarity among them all. The same likenesses, but in greater degree, are seen in the curves of mean velocity given in Fig. 3. The curves of discharge in each 20-ft. section show a more marked similarity. The effect of the difference in roughness between

the paved slope and the natural-earth slope is very clearly indicated in each set of curves. The section of deepest water and freest flow is also indicated by a high point in the curves.

Other curves show that the discharge in any 20-ft. station of the stream for any given stage bears a certain relation to the total discharge for the same stage, and nearly the same relation holds true whatever the stage of the river. For sections outside of approximately the middle third of the stream, the ratio of discharge in any section to the total discharge is nearly constant, except for very low stages.

In the main body of the stream, where the conditions of flow are such that the effect of friction is practically constant, the mean velocity of all sections is increased to the same fold for any change in state when the form of the curves showing this relation remains almost constant.

The paper is of particular interest in showing how an intimate study of a single discharge section of a river brings out the interesting features of stream-flow measurements. (*The Cornell Civil Engineer*, vol. 25, no. 4, January 1917, pp. 161-169, 5 plates, *et*)

Internal-Combustion Engineering

NEW ROTARY-VALVE ENGINE DESIGN

Description of the Van Keuren mono-valve engine which is about to undergo tests in one of the Detroit laboratories. It

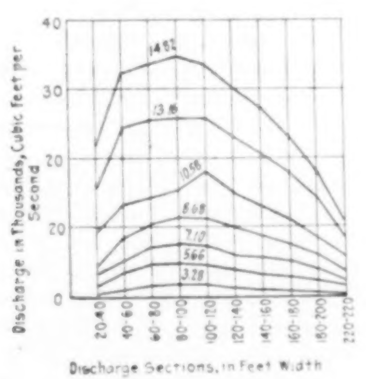


FIG. 4 DISCHARGE FOR EACH 20 FT. STATION

is of interest because of its use of an overhead rotary valve. The difficulty hitherto has been of properly cooling the valve, with the result that warping soon occurred and the engine failed. In this particular engine the cooling water is free to circulate through the entire length of the overhead cylindrical valve. The valve is lubricated by mixing the oil with the gasoline in the proportion of about 1 pt. of oil to 5 gal. of gasoline.

In this engine the cylinder block is suspended over the valve cylinder. In this way all upward reactions are transmitted to the valve and the valve operates under about 60 lb. maximum pressure per square inch of bearing area. The purpose of this is to allow the cylinders to seat upon the valve members and maintain gas tightness in the cylinder ports. In other words, the seating is directly opposite to that of the poppet-valve type, as the cylinders are brought to their seat inside of the valve. To eliminate the carbon troubles which have also been prevalent on overhead-rotary-valve engines, the valve is so shaped as to scrape the carbon from the seat as it is formed.

Another feature of an engine of this type is the possibility of obtaining proper combustion-chamber form. In this case the chamber is conical and machined all over. The spark plug at the side fires directly into the charge. (*The Automobile*, vol. 36, no. 8, February 22, 1917, p. 412, 1 fig, *d*)

THE HVID ENGINE, E. D. Blakely

Description of an oil engine invented in this country by R. M. Hvid and working on a cycle approaching that of the Diesel engine.

The engine is of interest because of the wide variations in fuel which it is able to use. The writer claims to have actually run a Hvid-type motor on the following fuels: kerosene, crude oil, fuel oil, road oil (35 per cent asphaltum), cod-liver oil, castor oil, lard oil, cylinder oil, melted butter, and thick cream. It is not claimed of course that all these fuels could

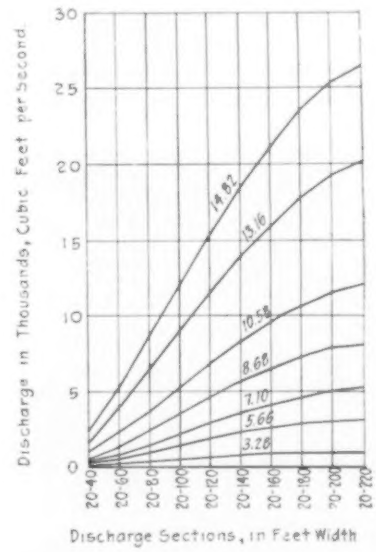


FIG. 5 TOTAL DISCHARGE PROGRESSING ACROSS STREAM

be used practically, but the fact that the engine will run on them speaks for the principles involved.

The Hvid-type motor may be made either four-stroke or two-stroke cycle. Ignition is secured by the heat of compression, but unlike the Diesel motors the Hvid motor requires no air compressor.

Fig. 6 is a cross-section of the Hvid injector valve, the extreme end of which projects into the combustion chamber and operates as follows:

On the suction stroke of the motor, pure air only is admitted to the cylinder through the inlet valve 1. While this air is being drawn into the cylinder, the fuel valve 2 is mechanically opened and some fuel flows out of a hole 3 into a steel cup 4, the amount of oil being controlled by the needle valve 5. The fuel valve 2 closes again just before the end of the suction stroke and seals hole 3. The compression stroke follows next and the air previously admitted to the cylinder is compressed to about 450 pounds per square inch, which renders it incandescent. The compression pressure enters cup 4 through holes 6 at the bottom of the cup, and a minute amount of the oil lying at the bottom of the cup is ignited by the incandescent air. The combustion which takes place gives rise to a pressure within the cup far in excess of the compression pressure in the cylinder, and the oil lying at the bottom of the cup is forced out of cup 4 through holes 6 into

the incandescent air in the cylinder, where it ignites spontaneously; the pressure arising from combustion forces the piston forward on the working or expansion stroke.

The Hvid cycle is as follows:

First, a charge of pure air is drawn into the cylinder at or near atmospheric pressure and temperature. During part of this suction stroke, fuel is admitted by gravity through a mechanically operated valve into a small steel cup, the inside of which is connected with the main cylinder by two small pinholes which are located at the bottom of the cup and point toward the piston. The amount of oil admitted is controlled by the governor by means of a needle valve.

Second, the pure air in the cylinder is compressed to between 400 and 500 lb. per sq. in., which gives rise to temperatures of from 950 deg. to 1050 deg. fahr.

Third, as the temperature of the air in the cylinder rises, due to compression, so does the temperature of the small amount of air which is in the steel cup, since the cup is connected by the two small pinholes with the main cylinder. There ensues then within the cup an ignition and combustion of a very small amount of the oil previously admitted to it.

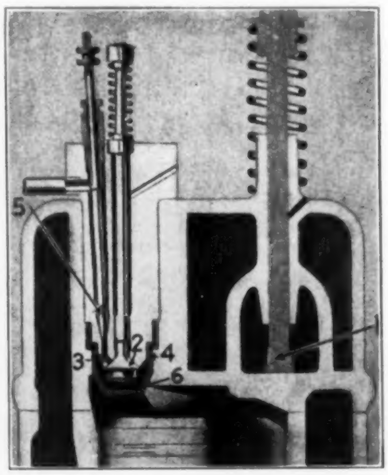


FIG. 6. CROSS-SECTION OF THE INJECTOR VALVE OF THE HVID ENGINE

(The amount of oil consumed by this preliminary or primary combustion within the cup must necessarily be infinitely small because there is not sufficient air in the cup to support the combustion of more than a minute amount.) As this combustion takes place, the pressure within the cup rises above that in the combustion chamber and drives the surplus oil out through the two pinholes in a heated spray, which, on coming in contact with the hot compressed air in the cylinder, ignites and burns at approximately uniform pressure.

Fourth, the products of combustion are exhausted. The cycle is then repeated.

It is stated that recently a test of a three-cylinder Hvid-type engine was made in Lansing, Michigan. The same size of engine operating as a conventional type of gasoline engine was rated at 60 hp., with a maximum output of 70 hp., but when converted into a Hvid type it showed a maximum output of 87 hp. and was rerated at 75 hp. The fuel consumption during this test with fuel oil as fuel was 0.42 pint per hp. The complete log of the tests is not given. It is also stated that the Hvid type can be built in units as small as 1 hp. (*Motor Boating,* vol. 19, no. 1, January 1917, pp. 25, 56 and 58, 2 figs., *d*)

A STANDARD OF CARBURETOR PERFORMANCE, Prof. R. C. Berry

Carburetor performance is often reported in terms of engine performance. This may serve the purpose when it is desired to compare the merits of different carburetors for use on a good engine, but it does not throw much light upon the performance of the carburetor itself. There ought to be established a standard of carburetor performance that would be expressed in terms of the ability of a carburetor to perform those functions for which it was designed.

The best carburetor is the one maintaining a sufficient volume to atomize the fuel properly, and at the same time adding just enough heat to gasify the mixture. The amount of vacuum required will depend partly upon the scheme used in atomizing, and partly upon the character of the fuel. The amount of heat required will also depend partly upon the way in which it is applied, and partly upon the character of the fuel.

Some experiments have been recently carried out in the laboratories of Purdue University, on a Haynes "Light Six" engine mounted on a Diehl electric dynamometer. The paper reports in detail the methods used in the tests. Curves similar to Fig. 7 were drawn in each case. In this figure the vertical (at 0.0671 lb.) represents the theoretically perfect mixture of fuel and air, or the one in which there is just enough oxygen in the air to burn the fuel, and no excess of either fuel or air. The curve shows that the engine will run with a *mixture* of less than 0.055 lb. of gasoline per pound of air, but will not pull well with so lean a mixture. As more fuel is added, the power will increase rapidly until nearly full power is reached, when the curve becomes almost horizontal, increasing slowly to a maximum, then decreasing slowly for a time but finally reaching a point where it falls off rapidly.

The richest mixture with which the engine could be run was 0.155 lb., or nearly three times as rich as the leanest mixture. In other words, a carburetor can be adjusted with as lean a mixture as can be used to carry full load, and the amount of gasoline can be nearly doubled without greatly affecting the power capacity of the engine. It is practically impossible to stand by the side of an engine mounted on a test block and distinguish any difference whatsoever in its performance as the mixture is being changed through this range. But the effect of this change upon the *efficiency* of the engine is very different. The point of highest efficiency seems to coincide almost exactly with the point of the theoretically perfect mixture. As the mixture is made richer than this the efficiency will decrease, even while the power is increasing slightly, and will decrease rapidly after the point is reached where the power is also decreasing.

Another set of curves given in the article shows that the mixture for maximum power is not noticeably affected at *half-load* by the speed, but that at high speeds the engine cannot hold up its power with quite as much excess fuel as at lower speeds. With a leaner mixture the power holds up equally well at all speeds.

The above curves offer the explanation as to why of two cars of the same make, and of equally good mechanical characteristics, one can travel 10 miles on a gallon of gasoline and the other 15 miles. This is because on one car the carburetor gets a powerful but lean and therefore efficient mixture; while the other carburetor receives too rich a mixture.

The following rule is suggested for adjusting a carburetor: Decrease the quantity of gasoline until the engine loses power; and then increase it slowly until good power is restored, but not a notch beyond this point. (*S. A. E. Bulletin,* vol. 11, no. 5, February 1917, pp. 556-564, 5 figs. *ep*)

Machine Parts

NOTES ON SCREW GAGES, Col. R. E. B. Crompton

Paper presented to the Institution of Automobile Engineers. It begins with definitions of various terms used in discussion of screw gages as adopted by the Engineering Standards Committee (Great Britain), and then, after a brief history, proceeds to the discussion of the various threads, such as the Whitworth and British Association (B. A.).

The writer points out that notwithstanding the work done at Woolwich, at the National Physical Laboratory, and elsewhere, when the war broke out there was no satisfactory system in use for gage making. If gages had at that time been so designed that they could have been cheaply and readily produced in quantity, England would have saved many thousands of pounds and much delay in the turning out of shells.

One of the opinions as to the causes of difficulty in producing gages in England was that the rounded roots and crests of the Whitworth form of thread require elaborate plants and form a costly item in gage work. The American Sellers form and the Continental International thread use an angle of 60 deg. with flats on crests and roots, for which gages are more easily made.

The writer states further that when the demand for interchangeable screw work for shells became so pressing that a large supply of accurately made gages became necessary, it was found that many of the gages proposed in Report 38 of the Engineering Standards Committee were very difficult to make, especially those parts where accurate machining or lapping of the grooved portions of the thread at crests and roots were supposed to be necessary and were insisted upon in many of the government speifications. Of all the gages the most difficult to make accurately are the full-form "go" gages. As regards the theory and practice of these gages, it is evident in the first place that in order to secure interchangeability and at the same time take the fullest advantage of any tolerances which can be allowed on the work, the "go" plug-and-ring screw gages should each follow the same mathematical outline which is most naturally defined by the theoretical nominal size and form of thread. The tolerances on the work should be such that all screwed plugs are on or below this size and all screwed holes on or above it. In practice, however, it is not possible to make either gages or work so perfectly that the plug and ring of the *same* mathematical size will screw together. Some tolerance needs to be allowed on the gages themselves, and reference and check gages have also to be considered.

As regards tolerances on screwed work, the writer believes that part of a tolerance is a fixed quantity, i.e., that made necessary by roughness of surfaces, films of dirt, or similar physical matters, and this applies equally to a small screw and to a large one. It follows that the proportion which this constant tolerance bears to the thread depth in the small screw is very large as compared with the same constant tolerance applied to the large screw. This was not at first realized, so that it was found in practice that although the tolerances for the large screws laid down in Report 38 are workable, those for small screws on the Whitworth or B. S. F. scale (½ in. to ¼ in.) and the B. A. series were far too fine and are practically non-workable.

Hence the writer suggests that the whole series of screws, from 3 in. down to the tiny screws used for instruments, should follow one law for tolerances modified only by considerations of the method of manufacture. Small tolerances or close fit on effective diameter are chiefly required to prevent the screws and nuts from working loose.

As regards clearances, although decisions on this point are urgently needed, nothing definite has been done.

It is further evident in the opinion of the writer that if high-crested taps having a core diameter somewhat above the nominal are used for all nuts, the high crests will insure triangular clearances at the crests of the male threads and the increased core diameter of the tap will reamer away the inner salients of the nuts so that the threaded surfaces of bolts and nut will come in contact only on the slopes. Their fit, therefore, is a question of the tolerances on effective diameter. The full diameter and core diameter of the bolts may take care of themselves and, if specified at all, very wide tolerances might be allowed on them.

But if we allow the above clearances before addressing ourselves to securing a good fit by tolerances graduated according to the requirements of the work on effective diameter, we can greatly simplify the gaging question by practically confining it to the gaging of the male screws by means of an

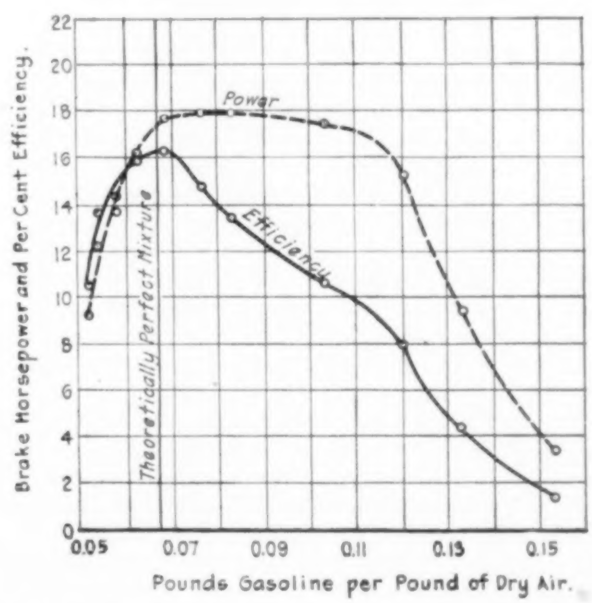


FIG. 7 ENGINE PERFORMANCE CURVES (1300 R.P.M.)

adjustable split nut accurately made as to pitch and thread form and cleared in such a manner that it only bears on the slopes of the threads that are to be tested and, therefore, tests the effective diameter only. Such a method of testing is not new but has rather been lost sight of.

As regards the gaging of nuts, the writer believes that the real gage for nuts is the tap, and nothing may improve screw interchangeability so much as improvement in tap manufacture. Errors in pitch introduced in the process of hardening taps must be minimized and a system of cutting the taps directly and accurately out of hardened blanks should be encouraged. (Paper presented before the Institution of Automobile Engineers, abstracted through the *Automobile Engineer*, vol. 7, no. 99, February 1917, pp. 35-37, *gp*)

Munitions

HEAT TREATING SHRAPNEL FORGINGS

Description of the methods used at the Hofman plant of the Symington Machine Corporation, at Rochester, N. Y.,

where 75-mm. Russian shrapnel are being made at the rate of over 15,000 per day.

The equipment for hardening the shell forgings consists of three twin-chamber, double-end, overfired oil furnaces built by the Metals Production Equipment Co., of New York. The combustion chamber of each of these furnaces is above the working chamber and is separated from it by a perforated arch of refractory tile. The oil is delivered from overhead feed lines to five burners at each side of a two-unit battery of furnaces. The oil is atomized by steam and delivered to the burners at 80 lb. pressure. The flame of combustion is retained in the combustion chamber and the heated gases flow down through the checked refractory arch into the working chamber containing the shell forgings. After circulating in this chamber the gases pass out through an outlet in the side wall into a duct under the chamber and up through flues in the other side wall to vents in the top.

The roughly machined forgings are placed in metal trays providing convenient means of quickly placing four shells at the proper distance apart so that the heat of the furnace may circulate between them.

Hydraulically operated cylinders push three trays of shells into the furnace when water under 70 lb. pressure is admitted to the cylinders.

After the furnace has been filled with trays of forgings each succeeding group of three trays that is pushed in through the door at the front pushes all the others before it so that the last one emerges from the door at the back. As the shells leave the furnace an operator inserts the hooks of a two-pronged rake into holes in each tray and by a quick movement pulls it forward on smooth ways to a stop.

The forgings are subjected to a temperature of about 1500 deg. fahr. for a period of one hour and twenty minutes. The following device is used for regulating the movement of the shells through the furnace. It was determined that in order to subject each group of forgings to the heat of the furnace for exactly the required length of time, three trays must enter the furnace every five minutes. To insure the strict observation of this schedule an electric gong was installed to warn the operator when it was time to place another group of trays in the furnace. The ringing of the gong is timed by a revolving drum driven by a small direct-current motor.

From the furnace the shells go into the quenching oil. The oil reservoir contains 8000 gal. of oil which is maintained at the uniform temperature of 120 deg. fahr. by an extensive circulating and refrigerating system.

All the furnaces are equipped with automatic recording pyrometers which are arranged on shelves in a room adjoining the superintendent's office.

An important feature of shell making is the formation of the conical-shaped nose of the open end of the shrapnel forging, and the mechanical method of pressing the open end of the forging owes its success to the physical properties imparted to the metal in the annealing process.

The article describes the general features of the annealing furnaces.

Among other things the writer calls attention to the fact that the previous work done to satisfy the exacting demands of automobile, locomotive, and machine-tool construction has brought the art of heat treating previous to the beginning of the present war to the stage which alone made possible the wonderful strides made in the new art of shell making in this country during the last two years. (*The Iron Trade Review,* vol. 60, no. 6, February 8, 1917, pp. 365-368, 6 figs, *d*)

Railway Engineering

Water Conditions in the Locomotive Boiler, George L. Fowler

Data of a recent study of boiler feedwaters on a railroad where there was a variety of troubles from this source. An important feature brought out by the investigation is the impossibility of depending on the analysis of the raw water as drawn from wayside tanks.

As regards the formation of scale, cases have been observed where the scale formed was of medium hardness and brittleness, and was easily removed from the surface to which it adhered by tapping it with the hand. Where the sheets were bare or the scale thin, there was no corrosion; but where the scale formed, corrosion took place beneath it forming a large pit as shown in Fig 8. The thicker the scale the deeper was the pit (Fig. 8).

As the water appeared harmless and the corrosion occurred only beneath the scale, it was surmised that the scale might be corrosive. A sample of it was analyzed (complete data given in original article), but nothing was found of a corrosive nature, and it would seem therefore that after the deposition of a certain amount of scale the plates beneath it became locally overheated. This caused a decomposition of the organic matter, the calcium sulphate and magnesium hydroxide forming free sulphuric acid, which is partially protected from dilution with the boiler water and attacked the sheets. The cure then lies in preventing an accumulation and adhesion of scale.

In another case there was little or no trouble from scale, but there was an intense and rapid corrosion that would destroy tubes by pitting in nine or ten months. The water that was doing this did not even give an acid reaction, and there was apparently nothing to account for the intensity of the action which actually took place. A lime-and-soda treating plant had been erected at one place, but the result appeared unsatisfactory.

After a rather thorough examination of analyses of the water, it was decided that something was happening in the boilers of which nothing was known. Two boilers were selected, the water of each of which had been taken from a single tank, and samples analyzed after having been in service for about eight days. The variation in the composition was startling, as shown by Table 1.

The water taken from the boiler was extremely bad. The free sulphuric acid coupled with a large quantity of organic matter fully explained the rapid corrosion that takes place in the boiler using the raw water from which it is formed.

Because of the uncertainty as to the uniformity of the quality of the water delivered to the boiler, an experimental small boiler, of about two gallons' capacity, was built, in which definite samples of water were evaporated. The boiler was operated under a pressure of 200 lb. per sq. in. The method of operation was to draw a quantity of water from the tank to be examined and analyzed; then to take 75 gal. of the sample and evaporate it to 1 gal. in the small boiler. Table 2 gives a typical result which presents a good example of the change repeatedly found to take place in water that has been subjected to the high pressure and temperature obtaining in a locomotive boiler.

While some compounds disappeared, others were apparently formed. In this case the raw water contained neither calcium sulphate nor magnesium chloride, and yet both were found in the water taken from the boiler. On the other hand, the sodium sulphate and magnesium carbonate disappeared. The

decomposition of the magnesium chloride formed hydrochloric acid, which directly attacked the sheets.

As to the decomposition of sodium sulphate, which may appear incredible, the writer states that in seven cases where these evaporation tests were made, each showed an apparent disappearance of the salt and the formation of new compounds that did not exist in the raw water.

In fact, an attempt was made to regulate this phenomenon. One of the worst of the waters was selected and subjected to the boiling test, followed by an examination. The raw water was then treated with sufficient barium hydroxide to precipitate all of the sulphates as barium sulphate. Again, a concentration test was made of 75 gal. of water thus treated, with the results given in Table 3.

These results show that notwithstanding the practical elimination of the sulphates and presence of a certain amount of organic matter, all of the sodium was retained in solution and combined with a liberated carbonic acid. Some of the sulphuric acid and silicic acid were present, making the water strongly foaming.

TABLE 1 ANALYSES OF WATER FROM TANK AND BOILER (AFTER 8 DAYS' SERVICE)

Impurities	Grains per gallon. From tank.	Grains per gallon. From boiler.
Calcium carbonate	0.29	....
Calcium sulphate	15.05	7.02
Magnesium sulphate	11.67	28.81
Magnesium sulphate (manganic)	....	10.61
Iron sulphate (ferric)	....	43.87
Alumina	...	45.15
Sodium sulphate	9.62	38.38
Sodium chloride	1.52	14.99
Sodium nitrate	....	0.12
Silica	1.51	21.93
Alumina and iron oxide	0.52	....
Organic matter	1.96	17.21
Free sulphuric acid	....	2.33
Total	42.16	230.42

TABLE 2 ANALYSES OF WATER FROM TANK AND EXPERIMENTAL BOILER

Impurities	Grains per gallon. Raw water from tank.	Grains per gallon. Concentrated water from boiler.
Calcium carbonate	1.34	0.73
Calcium sulphate	....	1.91
Magnesium carbonate	0.70	....
Magnesium sulphate	0.17	2.76
Magnesium chloride	....	1.74
Sodium sulphate	0.52	....
Sodium chloride	0.70	2.11
Sodium nitrate	0.07	0.57
Silica	0.58	5.47
Alumina and iron oxide	0.29	2.64
Organic matter	0.81	2.29
Total	5.18	20.24

For waters that did not lend themselves to successful tank treatment two methods were adopted to prevent the corrosive action, both of which appear to be working successfully. One is to make an examination of the water in the boiler each day and prescribe the amount of soda compound that is to be used. The examination requires only five to ten minutes' time and the application is made through a hose attached to the suction chamber of the injector. Enough of the compound is used to maintain the alkalinity of the water in the boiler at 0.3 per cent, which, while not entirely noncorrosive, is so nearly so as to avoid trouble.

The other and simpler method is to apply a corrosion inhibitive at each washout. If the boiler has been in service for some time and the corrosion has started, it has been found to require three or four applications to stop it. After that the water drawn from the boiler will be clear and free from oxides. Where this treatment is used and the water in addition to its corrosive qualities carries scale-forming matter in any quantity, it is necessary to add a scale preventive to the inhibitive. (*Railway Age Gazette*, vol. 62, no. 9, March 2, 1917, pp. 359-362, 1 fig. *ep*)

SOUTHERN RAILWAY DUPLEX LOCOMOTIVES

Description of the application of Mogul running gear and machinery to a Mikado locomotive.

By such an application the Southern Railway has materially increased the capacity of these locomotives without increasing the wheel load, and with a marked decrease in fuel consumption per ton-mile. This has been done with but little change to either the running gear of the retired engines or to the water tanks of the Mikados. The diameter of the cylinders of the tender engine has been reduced, which with the reduction of one inch in diameter of the Mikado-type cylinders, does not overtax the Mikado boiler to any extent. In addition to the reduction in cylinder diameter, the boiler capacity has been increased by the addition of brick arches and a feedwater heater which uses the exhaust steam from the air compressor.

TABLE 3 ANALYSES OF SPECIALLY TREATED RAW WATER AND WATER FROM EXPERIMENTAL BOILER

Impurities.	Grains per gallon. Treated raw water.	Grains per gallon. Concentrated water.
Calcium carbonate	1.11	0.70
Magnesium carbonate	0.11	0.05
Sodium carbonate	2.45	69.18
Sodium sulphate	0.58	57.87
Sodium chloride	0.76	9.91
Sodium silica	....	2.63
Silica	0.53	....
Alumina and iron oxide	0.06	0.53
Loss on ignition	0.40	4.14
Total	6.00	145.01

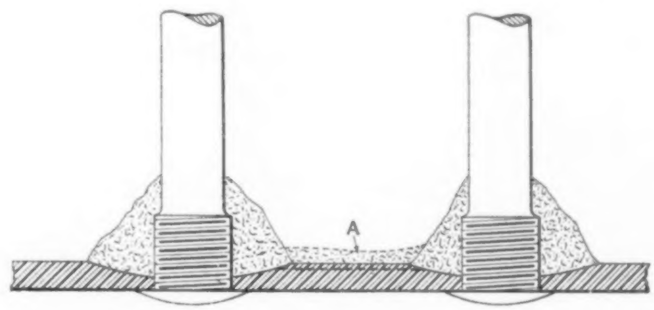


FIG. 8 SCALE FORMATION AND PITTING AROUND CROWN STAYS

Steam for the tender engine is taken directly from the superheater, through a well-lagged 3-in. pipe extending backward underneath the cap. A second pipe which permits the added use of saturated steam taken direct from the top of the boiler, is also connected with this pipe. This has been added in order to provide greater steam supply to the tender engine for peak loads on heavy grades.

With the application of the Consolidation running gear to the tender, the drawbar pull of the Duplex locomotives is made 39 per cent better than that of the original Mikados.

Several of these locomotives have been installed on the line between Asheville, N. C., and Hayne, S. C., a distance of 68 miles. On this line, eastbound, heavy-traffic direction, there are 1.5 and 1.7 per cent grades.

With the single Mikado locomotives the maximum tonnage handled over the first 22 miles of this line is 1100 tons. The Duplex locomotive will handle 1400 tons, or an increase of 27 per cent.

As regards the factor of adhesion in the Mogul, with the minimum weight of tender, it is much too low, viz., 2.25,

with the tender practically empty of water and coal. In the case of the Consolidation tender, the minimum factor of adhesion is about 3.25.

Fig. 9 shows the application of the Mogul running gear and machinery to the water tank of the Mikado-type locomotive. The entire lower part of the locomotive remains practically unchanged; the cylinder casting is retained intact, and the front and rear draft castings are changed slightly, the front draft casting being shown in one of the illustrations. A pocket is formed in the tank at the front end to provide a proper clearance for the rear cylinders. (*Railway Mechanical Engineer,* vol. 91, no. 3, March 1917, pp. 121-123, 6 figs. *d*)

Superheat in Locomotives

At the Fifty-Ninth Annual Convention of the American Railway Master Mechanics' Association held in June 1916 at Atlantic City, N. J., a report was presented by the committee on superheated locomotives, W. J. Tollerton of the C. R. I. & P. Ry., Chicago, Ill., Chairman.

This report provoked an interesting discussion.

D. R. MacBain (N. Y. Cent. R. R.) spoke of tests with locomotives equipped with Schmidt superheaters. An engine was taken of exactly the same type as those used without superheaters and an accurate account kept of every gallon of water and every pound of coal used, and also of every car that was moved about the station—as closely as was possible. An actual saving of fuel on superheated locomotives was found. No claim is made that any high degree of superheat was obtained on a switching locomotive, but this is what was found: On three different tests it was ascertained that even in the summer time, say for the month of September, there was a drop of approximately 25 per cent in the steam temperature from the time it left the boiler until it entered the cylinder. This was the result of the saturated tests. With the superheated switching locomotive this 25 per cent was taken up, or, in other words, it became possible to maintain on that slow-moving, short-work switching engine just about boiler temperature in the cylinder. The experience of that road so far indicated is that on short switching not much superheat is obtained, but that a vast saving is secured, due to cutting out the condensation, especially on a switching engine working with practically cold cylinders.

C. F. Giles (L. & N. R. R.) discussed the use of the drifting valve. It was found very difficult to get the engineers to use a cracked throttle in drifting down a long grade. An intercepting valve in the throttle was introduced with the expectation that it would be kept open when the main throttle was closed. This did not prove entirely satisfactory and, besides, the steam that is taken into the cylinder from the superheater units is naturally superheated and one cannot get as good results from superheated steam in drifting as with saturated steam.

In October 1915 an automatic drifting valve was applied with satisfactory results. In this case the pressure from the valve chamber keeps the valve closed when the engine is working steam. There is a spring on the opposite side that allows the valve to open when the pressure from the valve chamber is cut off. The valve is connected by a pipe direct to the dome which provides saturated steam continuously to the cylinders while drifting, with a branch pipe running from each side of this drifting valve to the valve chamber.

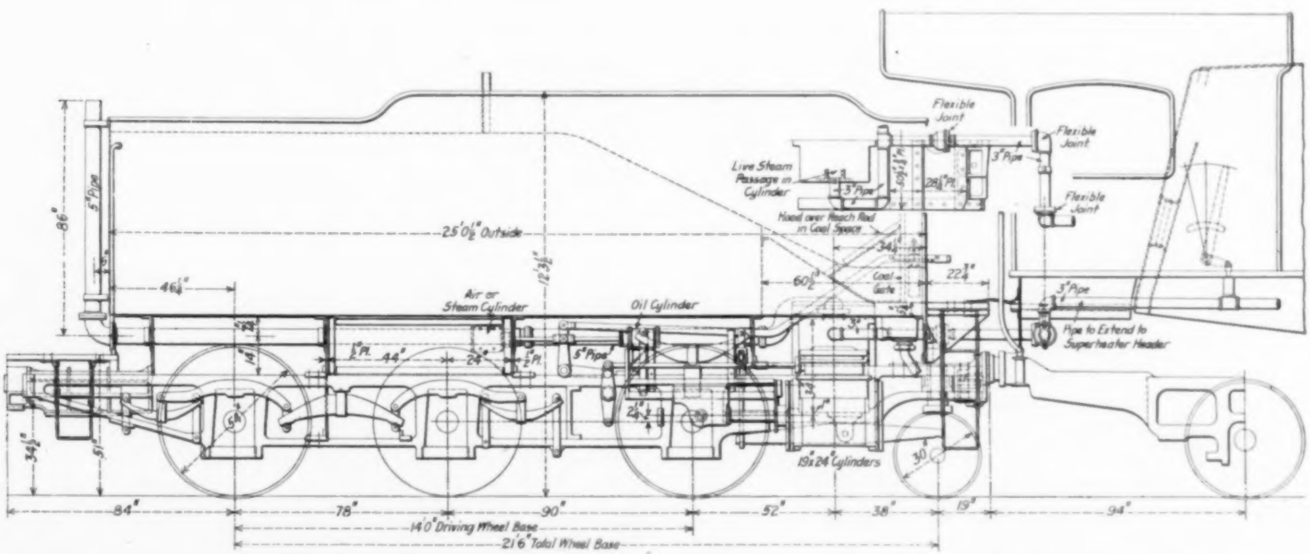


Fig. 9 Application of Mogul Running Gear and Machinery to Water Tank of Mikado Locomotive

The speaker had the valve chamber and cylinders on the first engine to which the valve has been applied opened up and found that they were lubricated as satisfactorily as any saturated engine he has examined.

H. C. Woodbridge (Assistant to Gen. Mgr., B. R. & P. Ry.) discussed the operation of slide-valve locomotives with high-degree superheat. About three years ago he tried a method by which the face of the valve and seat were bathed with lubricated saturated steam, and a circulation between the seat and the valve face established. He ran the engine using saturated steam for eleven months, testing it out as far as possible with a wide-open throttle and a short cut-off for long distances. A Schmidt superheater was then applied to that locomotive. Since the application the engine has made 35,000 miles, being handled during the past five or six months in pooled service, and in that pooled service the engine was allowed only 1¾ pt. oil for a 107-mile run. (The writer believes that this oil allowance should be increased to properly provide for irregular service.) The locomotive, a 40,000-lb.-tractive-effort consolidation engine, was then put in passenger service to see if the valves could be burned out. It performed

very satisfactorily on the fastest trains where it was necessary to run 53 to 54 miles per hour, which, with a small wheel, means 5 r.p.s. a good deal of the time. The same scheme was applied to an Atlantic-type passenger locomotive carrying 200 lb. of steam and is at present being applied on a Decapod pusher engine.

The writer expressed his belief that the distortion of a properly designed slide valve will not be sufficient to cause any trouble if it is properly lubricated. After the writer had found a slight distortion in the valves run with a superheater he was surprised to find just as much distortion in the same character of a valve with saturated steam.

R. P. Blake, speaking of his experience on the Northern Pacific, stated that observations of the performance of the engines led to the conclusion that there was little if any advantage in the five-feed lubricator. The same quantity of valve oil regularly and properly introduced into the cylinder through the valve would give better results than attempting to feed part of it into the cylinder direct. At present the results which are being secured in cylinder packing are probably averaging about 20,000 miles between renewals. (*Report of the Proceedings of the 59th Annual Convention of the American Railway Master Mechanics' Association*, Chicago, 1916, vol. 49, pp. 130-155, *g*)

Sieves

A Standard Screen Scale for Testing Sieves

Since the adoption by the Bureau of Standards several years ago of specifications for standard 100- and 200-mesh sieves, frequent requests have been received that this Bureau test and certify sieves of other sizes than these. With a view to the adoption of a series of standard testing sieves which might be of use to all industries making fineness tests, this Bureau for two years has been studying the question of such a standard screen scale. Various scales that have been proposed were considered, and information was sought of representative firms in the various industries interested as to their requirements. Manufacturers of sieves have also been consulted as to the desirability of different screen scales and the practicability of their manufacture. As a result of this study of the question, a conference was called at the Bureau of Standards April 20, 1916, of representatives of various committees of the American Society for Testing Materials, American Society of Civil Engineers, American Institute of Mining Engineers, American Foundrymen's Association, Mining and Metallurgical Society of America, American Water Works Association, American Institute of Metals, and the American Spice Trade Association; also representatives of the Committee of Revision of the U. S. Pharmacopœia, the U. S. Geological Survey, the U. S. Bureau of Mines, the U. S. Office of Public Roads and Rural Engineering, the U. S. Office of Grain Standardization, and the U. S. Bureau of Standards; also representatives of a number of private firms engaged in industries in which sieves are used, such as the glass, the drug-milling, the abrasive, the asphalt, the mining, the spice, the chemical, and the graphite industries; also representatives of the firms in this country manufacturing wire cloth and sieves.

This conference, after considering the various screen scales either proposed or now in use, adopted as a Standard Screen Scale that given in a table in the original paper, and recommends that it be adopted generally by scientific, technical, and engineering societies and committees, and by branches of national, state, and municipal governments as a part of their specifications for materials and methods of tests; also that it be used by private firms who have need of standard sieves.

This screen scale is essentially metric. The sieve having an opening of 1 mm. is the basic one, and the sieves above and below this in the series are related to it by using in general the square root of 2 (or 1.4142), or the fourth root of 2 (or 1.1892), as the ratio of the width of one opening to the next smaller opening. The first ratio is used for openings between 1 mm. and 8 mm., while the fourth root of 2 is used as the ratio for openings below 1 mm. to give more sieves in that part of the scale. The series has been made large enough, it is hoped, to meet the needs of all industries. Some industries may have occasion to use all the sieves in a certain section of the series and none of the others, while in other industries it may be desirable to use only certain sieves selected from the whole range of the series. In making such selections it is recommended that this be done on some systematic plan, as, for example, the selection of every other sieve or of every fourth one in the series below 1-mm. opening and every other sieve above 1-mm., in which case the ratio of each opening to the next smaller one would be as two to one.

Because of the wide range of openings in sieves now manufactured which are possible with a given number of meshes of wire per unit length by the use of wires of different diameters, and the consequent confusion and uncertainty which arises in designating sieves by the number of meshes per unit length, the sieves of this series have been designated by the width of the opening in millimeters, as, for example, a 1.41-mm. sieve, or a 0.36-mm. sieve. It is urgently recommended that all users of sieves in the future designate these standard sieves in this way and that the manufacturers mark and list the sieves in this manner rather than by the meshes per inch.

In the designation and certification of the sieves the metric units will be used by the Bureau of Standards. In the table (in the original paper), however, are also given the equivalents of these metric quantities in inches in order that the series may be more readily related to work previously done. It is, of course, immaterial whether units of the metric system, or of the customary system, or of any other system are used in the manufacture of the sieves provided they are within the tolerances.

To meet the need for sieves of this series at the present time a temporary provision has been made in the specifications for the acceptance of sieves of slightly different mesh and wire diameter than those called for in the screen scale, provided the resultant opening is the same as the nominal opening within a small range. This will make possible the use of a number of sieves now on the market in which the ratio of wire diameter to opening is only slightly different from that of the screen scale. This provision will be withdrawn when conditions are such that the manufacturers of sieves can furnish sieves made more exactly in accordance with the specifications.

The Bureau of Standards hereby announces that it will test sieves of this series to determine whether they conform to specifications given below. This test will consists of the examination of the mesh of both the warp and shoot wires of the cloth to ascertain whether it comes within the tolerances allowed; also measurements of the diameter of wires in each direction to determine the average diameter, and a measurement of any large openings to ascertain whether they exceed the limits given in these specifications; also an examination of the sieve to discover any imperfections of the sieve which

may seriously affect its sieving value. Sieves which pass the specifications will be stamped with the seal of this Bureau and will be given an identification number, and a certificate will be furnished for each sieve that passes the requirements.

For sieves which fail to meet the specifications, reports will be rendered showing wherein the sieve was not up to the standard.

A fee of $2.00 per sieve will be charged for the test of the sieves when submitted singly. For from two to nine sieves submitted at one time the fee will be $1.50 per sieve. For lots of ten or more the fee will be $1.00 per sieve. Only half of the above fees will be charged for such sieves as may be rejected for exceeding the tolerances of mesh, in which case the wire diameter will not be measured. (*Abstract from an advance notice supplied by the Bureau of Standards,* Washington, D. C.)

Steam Engineering

Ford Boiler and Gas Plants, Thomas Wilson

In the Ford boiler plant seven of the largest boilers yet to be put in operation are in the course of erection. They are of the Badenhausen six-drum type, with six passes over the gases and with 25,000 sq. ft. of heating surface. While rated at 2500 hp., it is proposed to operate them continuously at 4000 hp. Steam will be generated at 180 lb. pressure and superheated to a temperature of 600 deg. fahr.

The article describes in detail the system of location of the boilers, which permits of an important economy of space.

Each boiler will be served by a 12-retort Taylor stoker of especially large size, driven by a variable-speed motor through a silent-chain drive. Clinker crushers are provided with a 5-hp. constant-speed motor at either side, with the drive by belt, gear box and ratchet, the throw of the latter being adjustable.

The water-back is of special design. It consists of two headers in the open space at the rear of the bridge wall, with $3\frac{1}{4}$-in. U-shaped tubes placed $6\frac{3}{4}$ in. apart passing through the bridge wall and projecting far enough to prevent clinkers coming in contact with the brickwork. Expansion is taken care of by arranging the brickwork to give a space of $\frac{1}{2}$ in. around the tubes, which space is packed with asbestos. By drawing them into the furnace the tubes can be removed without seriously interfering with the bridge wall. The headers are flexibly connected to the boiler by long bends and provided with handholes through which the tubes may be expanded or cleaned.

As the feedwater enters at the rear, the coldest water in the boiler goes to the water-back. The flow enters into and assists the regular circulation of the boiler. There are four blow-off connections to each boiler: two on the lower drum of the economizer section, and two on the lower drum of the boiler proper.

To obtain the high superheat anticipated, a Superno superheater is located between the first and second passes, or in the path of the gases just after the first bank of tubes. To obtain uniform heat transfer, a superheater is made up with an increasing number of tubes of decreasing diameter, the constant area approximately equal to the steam-outlet area from the boiler.

Between the third and sixth passes is located a damper hinged on to the boiler side and closing against an angle iron on the division wall between the two lower drums. Normally, this damper will be closed, and all of the gases will flow through the six passes of the boiler. Should the draft be lower than usual and it is desired to reduce the drop through the boiler, the damper will be raised so that a portion of the gases will enter directly from the third into the sixth pass.

When the plant is complete, the intention is to induce the draft by utilizing the exhaust from the gas engines. It is expected that the temperatures of both exhaust and stack gases will approximate 300 deg. fahr., so that the exhaust will be called upon to increase the draft.

In the small Wickes boilers, also, the steam is generated at 180 lb. pressure and superheated to 600 deg., with the boiler feedwater raised to a high temperature in the gas-engine cylinder jackets and the feedwater heaters.

The heat in the stack gases is utilized in an air preheater rather than in an economizer. The preheater consists of a rectangular sheet-iron box with tube sheets and 190 tubes of $3\frac{1}{2}$ in. outside diameter, placed on 6-in. centers both ways, set in the uptake from the boiler. The gases pass through the tubes. The air from the fan comes in at the side of the preheater, flowing across the tubes and back to the outlet, thence down through a duct to the wind box of the stoker. A series of sleeves with baffle flanges fit over the tubes to increase the area of contact, and to stratify the air so that all the surface will be used to advantage.

In the water heaters each unit is divided into four elements, receiving the exhaust and the jacket water from three engines. The gases pass through the four elements in series countercurrent to the flow water. It is estimated that they will enter at the temperature of 550 deg. fahr. and leave at possibly 300 deg. The water leaves the gas-engine jackets at an average temperature of 195 deg., and it may reach a temperature of 275 deg. in the heater before being delivered to the economizer sections of the boilers.

The article describes in detail the ash- and coal-handling equipment and the gas-producer plant. In connection with the latter, it is stated that recently an experimental producer was built to make gas which would not require scrubbing apparatus. The outfit consists of a standard Hughes producer, fed with coal and discharging gas to another producer of special construction charged with coke, the tarry vapors in the gas from the first producer being fixed into permanent gases by passing through the bed of hot coke in the second machine. This unit is now in operation. (*Power,* vol. 45, no. 8, February 20, 1917, pp. 239-243, 5 figs. *d*)

Large Modern Steam Power Plant

Description of a large power plant of the Buffalo General Electric Company, the interest of which lies in its use of a pressure of 275 lb. and a superheat of 275 deg., together with a general discussion on the future of high steam pressures.

A consideration of the general state of the art of steam-power generation tends to indicate that except for the gain of 10 or 12 per cent that might be added by increasing the heat range by going to higher pressures or higher superheat, there appears to be at present no other source for bettering the economy of the steam plant.

The passage from the high pressures of today, 180 to 225 lb., to such as 600 lb., is not likely to come in a single jump, as it requires suitable materials of construction and a change in the whole steam side of the station. Further, because with pressures like 600 lb. the dew point is advanced much nearer to the comparatively inefficient high-pressure

stages of the turbine, there appeared to be serious obstacles in the way of an immediate increase to 600 lb., or thereabouts. It is, however, likely that in the near future, large turbines will be ordered so designed that a high-pressure wheel may be put on if it is desired to increase considerably the boiler pressure after installation, as has already been done at Boston.

The writer discusses in this connection the various features of high-pressure and high-superheat turbines, such as turbine materials and wheel friction. As to this latter the writer calls attention to the experiments of Konrad Anderssen, who found that the resistance to rotation in the wheel is approximately proportional to the density of the steam, and that it increases with the fifth power of the diameter of the wheel and the third power of the revolutions.

From this the writer passes to the description of the Buffalo plant. While much of the power required for the industries at Niagara Falls, and for some at Buffalo, has heretofore been exported from the Canadian side of the Niagara River, the Canadian authorities have curtailed the sale of this power to American industries, and for this reason to the other head. One connection from each header joins a receiver at each turbine, with which 15-in.-diameter bends connect the turbine. The figure shows how well provided is the piping for the movement that 275 lb. pressure and 275 deg. fahr. superheat make inevitable.

All valves on the main steam piping except throttle valves are gate valves. The valves in the high-pressure steam lines are all steel. Although the steam velocities are not unusually high, the valves have been provided with seats designed to minimize the cutting and scoring effects of wire-drawing. The article illustrates various types of valves used, such as the boiler drumhead stop and check valves having the disk for seat screwed in instead of formed or pressed in, and seats, disks and stems of monel metal.

As regards boilers, the rate of coal feed by the plungers with the boilers operating at normal rating is 127 lb. per retort per hour. The stoker is capable of being operated to feed 1000 lb. of coal per retort per hour. When feeding 700 lb. per retort per hour, or 10.5 tons per boiler per hour, the boiler will evaporate about 160,300 lb. water per hour, from and at 212 deg. fahr., or 14.4 lb. per hour per sq. ft.

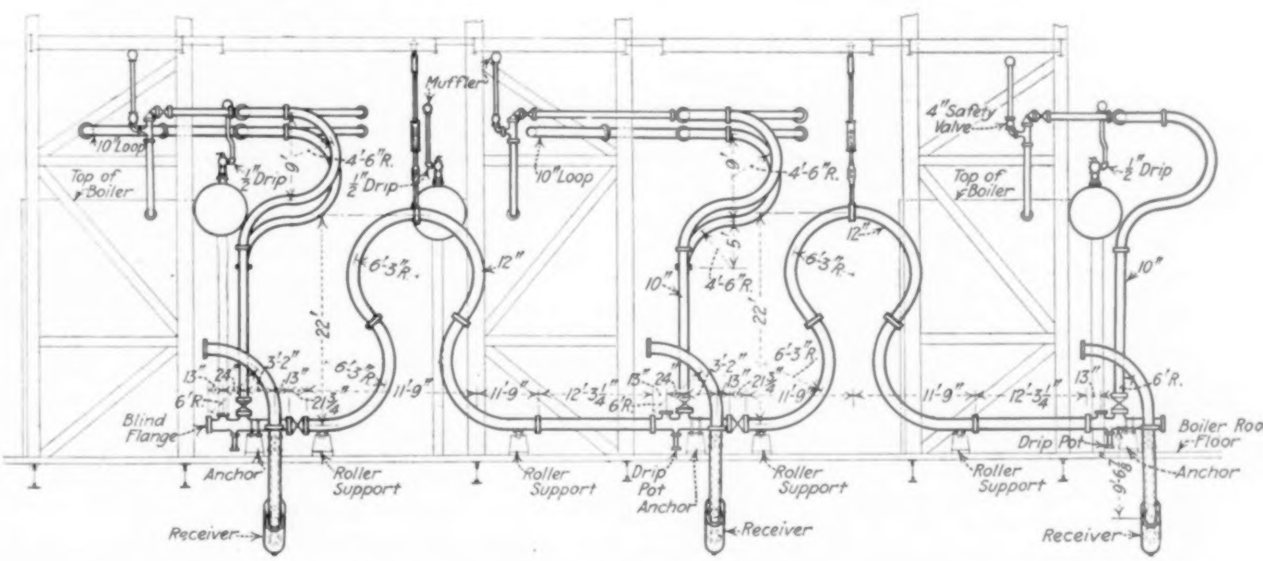


FIG. 10 ELEVATION OF STEAM MAIN AND LEADS FROM THREE BOILERS, BUFFALO GENERAL ELECTRIC COMPANY

the River Station of the Buffalo Electric Co. was built on Black Rock just outside the city limits of Buffalo, N. Y. The station was planned for 200,000 kw. capacity, 3 units each of 20,000 kw. at 90 per cent. power factor being installed initially; future units are to be 30,000 or 35,000 kw.

As regards time of construction a world's record has likely been made. The ground was broken for this work in January, 1916, and the station was put in commercial operation in November of the same year, a truly remarkable performance even in normal times, and especially when one realizes that the conditions of steam temperature and pressure require a considerable amount of special material.

An interesting feature is the high-pressure steam piping. As one stands facing the boiler-room wall, the bends in the 12-in. steam mains rise 23 ft. above the floor, as high as the boilers. Each bend, as shown in Fig. 10, consists of three parts, two 45-deg. bends from the horizontal, joined by a U-bend of 6ft. 3 in. radius, producing a double offset bend with four joints. There are two 12-in. headers, the 10-in. leads from the boilers at one side of the house going to one of these; the leads from the boilers on the other side going of heating surface. Hence, overload capacities can be obtained which would have been deemed impossible a few years ago. In fact, these boilers are heavily over-stokered as compared with usual practice.

The raw-water evaporator system for supplying distilled make-up feedwater is of interest. The purpose of it is to prevent formation of scale in the boilers or elsewhere in the system. This make-up water evaporator system has a capacity of 30,000 lb. of distilled water per hour, 24 hours per day. Distillate to have less than five grains of solid matter per U. S. gallon upon evaporation to dryness.

The diagrammatic layout of the evaporator plant is shown in Fig. 11. In the evaporator proper, the coils are of 1-in. outside-diameter seamless drawn-brass tubing wound in small coils so as to be quickly detachable. It is in the evaporator that most of the scale is formed and from which the sludge is blown to the waste pipe. The steam pressure is 275 lb. from the boilers, and the superheat 275 deg. As the heat transmission from superheated gas such as this steam is not as great as when saturated steam is used, a reducing valve and a de-superheater are used to reduce the steam to saturation at

200 lb. before it goes to the evaporators. One should, to facilitate his understanding of the system of Fig. 11, begin by tracing the lines from the raw-water line, or start at the hot well and trace the course of the condensate from the hot well of the turbine condensers through the evaporator system condenser, and to the main open feedwater heaters, from which it goes to the economizer and then to the boiler. The raw water which is taken from the circulating water discharged from the main condensers, enters an open heater supplied with steam from the exhaust of the auxiliaries and then passes through a heated generator, the shell of which is supplied with vapor from the second-effect evaporator, while the raw water passes through the opening of each evaporator.

The evaporator system is practically automatic in its operation, and the evaporators may follow very closely without personal attention the output as required by the load on the plant, or in accordance with the feedwater requirements.

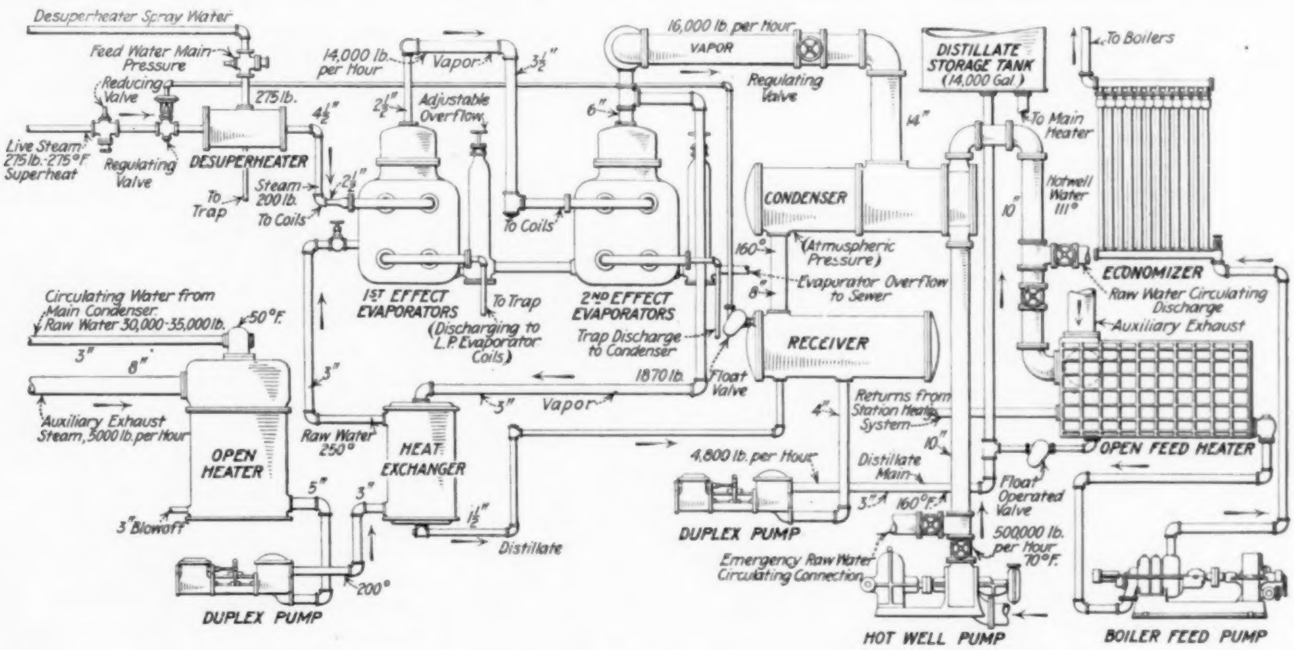


Fig. 11 Diagrammatic Layout of Make-up Water Evaporator System Handling 30,000 lb. Distillate per Hour, Buffalo General Electric Company

(*Power*, vol. 45, no. 7, February 13, 1917, pp. 202-212, 11 figs. *dg*)

Varia

Scientific Problems Awaiting Solution

Henry le Chatelier, in a recent address to the French Academy of Sciences, indicated certain scientific problems with special reference to French engineering which still await solution.

The French industries are now actively interested in attempts to produce laboratory glass, which hitherto used to be imported from abroad. At present they are only melting experimental masses at a considerable cost in time and money. At the same time it is known that the main property of glass on which depends the entire success of production is the extension of the range of its fusibility. Preliminary measures of the variation of the viscosity of glass as a function of temperature and chemical composition would be of inestimable value, in that they would reduce the necessary number of experiments on a commercial scale, and while these latter experiments cost hundreds of francs each, laboratory experiments could be carried out in small platinum crucibles with a dozen grams of material, and would cost quite little.

The same methods could be used for the preparation of test pieces for the determination of expansion, which is of such great importance in ceramics, and for the determination of electrical resistance in insulators, and of chemical stability, valuable in chemical analysis.

Here, in the opinion of the speaker, lies a field of scientific work of the greatest value.

Metallurgy. Penetrating projectiles used in the navy must have a very hard tip in order to pierce surface-hardened armor plate. Hence, in order to control the production of these projectiles, it is necessary to have a method of measuring the hardness of heat-treated steel. As a matter of fact, we have not got it. The least unsatisfactory of all that we have at present is the Shore scleroscope, which uses the rebound of a small steel projectile having a diamond-pointed end. The results are, however, not comparable, since in addition to hardness they are affected by various elementary factors, especially the shape of the pieces tested.

The study of the behavior of elastic bodies under shock is a matter of great interest, but so far as this problem is concerned, knowledge has scarcely advanced beyond where it was left by Leonardo da Vinci. The rebound amounts, on the average, to three-quarters of the height of fall, varying from 60 to 90 per cent of this height. Calculus, together with experiments, would no doubt rapidly advance our knowledge and supply means for determining the conditions under which the rebound would depend only on the hardness of the surface of the body measured.

Pyrometry. The measurement of heat and temperatures acquires a constantly growing importance in the industries. Each one of our shops for heat-treating projectiles uses a good many pyrometers. Unfortunately, their indications are not as precise as would be desirable. One cannot use the standard

gas thermometer, which is too complicated for use outside of physical laboratories. The Siemens-Callendar platinum thermometer is very exact, but too fragile for everyday use in shops. The only three types of pyrometers exclusively used in shops are the thermo-electric, optical, and calorific radiation pyrometers. But their readings are not sufficiently exact.

Their defects are not due to the capricious action of natural laws. The laws are absolutely uniform in their action, but several elementary factors or several independent variables act simultaneously, and should we happen to neglect any of these factors, or even to fail to make sure that they remain absolutely invariable, we would obtain results necessarily lacking in precision, in accordance with the greater or lesser importance of the neglected factors.

The thermo-electric force of a couple depends, above all, on the temperature at the welded joint, but also, in a lesser degree, on the law of distribution of temperatures along the conductor between the hot weld and the cold weld. This is a phenomenon which we know qualitatively, but its quantitative investigation is still to be made.

The homogeneous wire heated in the middle under such conditions that the gradient of temperature differs from one part of the heated zone to the other, generates a parasitic thermo-electric force, and this phenomenon varies in intensity with the nature of the metal used.

The readings of the optical pyrometer depend on the emissivity of the bodies observed. Hitherto the emissivity of three bodies has been determined: platinum, oxide of iron, and oxide of nickel. A good many other common bodies are still to be studied.

The results obtained with a radiation pyrometer are affected by the variable distribution of temperatures in the metal box of the apparatus. This factor is yet to be studied, and it is also necessary to determine the conditions required to eliminate this disturbing cause.

Heating. The heat conductivity of materials used for walls of commercial furnaces, and also that of the masses of coal burned on the grates, are essential factors in the problem of proper utilization of combustibles. The conductivity of metals is known, but for refractory materials we have only empirical data which vary as much as 100 per cent in accordance with conditions of manufacture. There is no information at all, even empirical, as to the heat conductivity of the masses of coal; and still this conductivity is an essential factor in the important matter of the possibility of burning out the grate bars. To make these measurements really scientific, it would be necessary to carry out experiments on heaps of spherical balls of known constitution, systematically varied as to diameter and temperature. In this way it would be possible to determine the laws of transmission of heat through porous masses, of radiation, convection, and of conduction proper.

In the course of the same experiments one could determine the laws of flow of gases through masses of this character; and the results obtained would be used not only for heating but also for the selection of molding sands and in other problems.

The author discusses in a similar manner certain problems affecting agriculture. (*Quelques problèmes scientifiques à résoudre,* Henry Le Chatelier, *Le Génie Civil,* vol. 70, no. 6, February 10, 1917, pp. 95-96, *g*)

Detinning Apparatus

Prior to the war steel scrap in the form of cans, etc., was shipped from England to Germany for removing the tin, solder and zinc. The following apparatus has been recently patented in England to do the work at home.

The apparatus essentially consists of a slowly rotating inclined cylinder and a stationary hopper with a sleeve encircling the rotating cylinder. The latter has a feed aperture which once in every revolution registers with the aperture on the hopper and allows the cans to be fed into the internal heating chamber. To reduce the friction the latter is mounted upon roller bearings. The heating is effected by gas or oil burners.

The heating chamber is surrounded by a firebrick-lined cylinder with outlets for the products of combustion through the short flues at the top. Cans feed into the heating chamber, gravitate slowly through as the chamber rotates, and eventually find their way to the outlet where they pass down the chute. The temperature is gradually raised along the length of the chamber and is the highest at the outlet end. In the interior of the heated chamber channels are formed for collecting the molten tin and solder. *Aeronautics,* vol. 12, no. 170, January 17, 1917, p. 55, 1 fig., *d*)

American Institute of Mining Engineers

The 114th Meeting of the American Institute of Mining Engineers, which was held in New York City, Feb. 19 to 22, was one of public, technical and social interest. The general or public interest of the meeting was more than is usually the case, due to the activities of the Institute in connection with public affairs as well as to papers of general interest, as for example: a new source of potash supply (the isolation of Germany has cut off the chief source of this material); a study of the world's reserves of manganese ores and of petroleum; and finally a research on the subject of erosion of guns. This latter paper attracted the interest of members of the Naval Consulting Board, of experts of the United States Army and Navy and of the Spanish Military Commission, many of whom attended the meeting and discussed the paper. General interest also centered around the personality of Herbert C. Hoover, Chairman of the Commission for Relief in Belgium, who, since before the war, has been a Vice-President of the American Institute of Mining Engineers and who was guest of honor at the Reunion Smoker and at the Annual Dinner, where announcement was made that he had been elected an Honorary Member. Finally, ladies of the families of members of the Institute gathered to the number of about one hundred, and formed a Women's Auxiliary of the A.I.M.E., "for service along any lines which may prove useful now or in the future to the country or community or to humanity at large." The activities of the Auxiliary are being extended to every part of the globe where mining engineers and their families reside.

The technical interest of the meeting is indicated by the fact that eighty-five per cent of the papers presented were discussed. In some cases the discussion was more important, and in some cases more voluminous, than the paper which brought it forth.

The social features of the meeting included a Reunion Smoker, on Monday evening; the Annual Dinner, on Tuesday evening; an Exhibition of Moving Pictures in colors, on Wednesday evening; Luncheon for all members and guests, including the ladies, on each day; and finally, an All-Day Excursion to the West Point Military Academy, by special train, on Thursday, Washington's Birthday, where the members and guests were royally entertained by the Superintendent and his staff, and where they had the opportunity in

return of entertaining these officers at luncheon. Other most enjoyable occasions in connection with the meeting consisted of a visit to the magnificent Art Galleries of Senator William A. Clark and Henry C. Frick, Esq.; Tea and Exhibition Ice-Skating on the roof of the Waldorf-Astoria; a theatre matinee for the ladies; and a visit to a moving-picture studio.

Bradley Stoughton,
Secretary.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connecion with articles reported in the Survey.

A new society under the name of the American Institute of Weights and Measures has been organized, with the purpose of opposing the introduction of the metric system in the United States.

The following officers were elected: President, W. R. Ingalls; Vice-Presidents, Henry D. Sharpe and D. H. Kelly; Treasurer, Walter M. McFarland; Secretary, F. A. Halsey.

According to a statement given to the press by State Engineer (New York State) Williams, daily service on the new Barge Canal between Buffalo and Albany will be begun in May. This will mean direct barge connection between the Great Lakes and the Port of New York, although facilities for the reception of all classes of freight will not be provided until next year. Freight rates will be approximately two-thirds of the railroad carrying charges.

In anticipation of the early need of cars of higher average capacity than those now in common use, the Pennsylvania Railroad, according to the *Railway Review*, has constructed a hopper gondola car of eighty-five tons capacity. This particular car has been constructed as an experiment, but if should prove successful, will serve as a model for future coal-carrying equipment. The design involves the use of four-wheel trucks and imposes loads thereon in excess of 60,000 lb. per axle, which approaches very nearly the limits recognized in locomotive construction.

When a modern large gun is fired with nitrocellulose smokeless powder, the temperature of combustion reaches from 4,000 to 5,000 deg. fahr.; and if the powder contains 25 per cent of nitroglycerine, it may rise to 5,000 to 6,500 deg. Steel melts at 2,650 deg. fahr., and a thin film of steel is fused in about one-sixtieth of a second. As soon as the projectile has left the gun, the big outflow of gas washes away a portion of this thin film of fused steel, and the bore is thus enlarged 0.001-in. in a 14- or 16-in. gun at each shot. With 58 per cent nitroglycerine, as in some English powders, the erosion is much greater.—Hudson Maxim, at the A.I.M.E. Annual Meeting, New York, Feb. 21, 1917.

The Pennsylvania Railroad has recently installed at Pitcairn, Pa., a novel type of plate-fulcrum track scales. This form of construction eliminates the knife edges which have been practically universally employed in scales of all kinds. In consequence of this change, the need of regrinding and renewing knife edges and bearings is done away with.

The place of the knife edge is taken by a thin plate continuous from lever to bearing. These novel plate fulcrums consist of relatively thin central portions connected to heavier portions or heads. The thin portion gives the desired flexibility, while the large heads distribute the load on the supported members and decrease the unit stresses. The design is such that the necessary vibration is taken care of without need of such wear as takes place in a knife-edge scale.

As a result of experiments recently carried out at the Consolidated Gold Fields Laboratory, an easy, cheap, and effective method of removing iron oxide from corroded and pitted iron plates has been evolved. Previous practice on the Rand has been to remove this mechanically, either with hammers, chisels, or a sand blast. While largely efficient, each of these methods is liable to leave traces or nodules of rust, especially at the bottom of the pitting, and these nodules prevent the covering of paint adhering to the iron and form nuclei for further corrosion.

The method evolved consists in applying to the surface of the iron a mixture of finely crushed sodium bisulphate and common salt, in the proportion of two parts of the former to one of the latter. This mixture is prepared, then wetted (just sufficiently to be cohesive) and applied to the iron plate. If time be no object, the moist mixture can be left until the plate is clean, but the action is much more rapid if the mixture is scraped off every two or three hours and the iron scrubbed thoroughly with a wire brush, applying water at the same time. The treatment is repeated until the plate is clean. Usually 24 hours is sufficient for a badly corroded plate.

The liberation of hydrochloric acid takes place slowly, and its action on the metallic iron appears to be slight.

When the plate is thoroughly clean it is washed well, finally with an alkaline solution, and dried quickly. A coating of paraffin oil is at once applied to protect the surface against atmospheric action. The metal is then ready for application of paint or other protective covering.

At the College of Engineering of the University of Minnesota a new educational experiment is being tried in the application of the task-and-bonus plan to the departments of shop work and design. Every job given to a student carries with it the time allowed, which is estimated on a fair basis. Any time saved by the student is given to him as a credit by means of which his time in college may be shortened if he accumulates a sufficient amount. It is assumed that the best men can save one-third of the time; and on the other hand if they prefer to do more work and not use the credit in reducing the time spent on the subject they can get one-third more value out of the course.

Prof. J. J. Flather reports that the system is working well both in the shop and drawing room and that all the instructors are enthusiastic in its application. The output per individual is at least 25 per cent and in some cases 50 or 60 per cent more than was the average before the scheme went into effect. There is an increased enthusiasm on the part of the men; their ambition is stimulated, and no drop in the quality of the work has been apparent. In fact, there is a strong tendency to maintain a high standard because additional credit is given for superior work and an extraordinarily good man may earn one-third bonus for quality in addition to the bonus he may earn for quantity.

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

THE CASE FOR THE LARGE AEROPLANE, F. Handley Page. Flight, no. 425 (no. 7, vol. 9), February 15, 1917, pp. 161-164.

ENEMY AIRCRAFT ENGINES. The Automobile Engineer, vol. 7, no. 99, February 1917, pp. 32-34, 5 figs.

LES ALBATROS. L'Aérophile, vol. 25, nos. 1-2, January 1-15, 1917, pp. 6-10.
The Albatros aeroplanes.

LE BIPLAN ALLEMAND RUMPLER, Jean Lagorgette. L'Aérophile, vol. 24, nos. 23-24, December 1-15, 1916, pp. 365-379, 39 figs.
The German Rumpler biplane.

L'ETAT ACTUEL DE L'AÉRODYNAMIQUE, L. Marchis. L'Aérophile, vol. 24, nos. 23-24, December 1-15, 1916, pp. 382-385.
The present state of aeronautics.

THE THOMAS 150 HORSE POWER MODEL 88 AEROMOTOR, George H. Abel. Aviation and Aeronautical Engineering, vol. 11, no. 2, February 15, 1917, pp. 88-90, 5 figs.

I DIRIGIBILI TEDESCHI, Biego di Costa Bissara. Rivista di Aeronautica, vol. 11, no. 5, September 15, 1916, pp. 116-120, 8 figs.
German dirigibles.

WATER AND AIR-COOLED AVIATION MOTORS, Henry M. Crane. Journal of the Aeronautical Society of America, vol. 1, nos. 8-12, August-December, 1916, pp. 20-22.

THE SUPERIORITY OF THE EIGHT CYLINDER V MOTOR FOR AERONAUTIC WORK, G. C. H. Goode. Journal of the Aeronautical Society of America, vol. 1, nos. 8-12, August-December, 1916, pp. 17-19, 3 figs.

A RÉSUMÉ OF A FEW INVESTIGATIONS CONDUCTED ON MATERIALS USED IN AEROPLANE CONSTRUCTION, James S. Macgregor. Journal of the Aeronautical Society of America, vol. 1, nos. 8-12, August-December, 1916, pp. 3-12, 8 figs.

SOME NOTES ON HIGH-PRESSURE AVIATION ENGINES, Leigh M. Griffith. S. A. E. Bulletin, vol. 11, no. 5, February 1917, pp. 529-543.

THE EVOLUTION OF AIRPLANE WING-TRUSSING, F. W Pawlowski. S. A. E. Bulletin, vol. 11, no. 5, February 1917, pp. 516-528, 45 figs.

SUGGESTIONS FOR STANDARD TESTS OF AIRPLANES, Jno. J. Rooney. S. A. E. Bulletin, vol. 11, no. 5, February 1917, pp. 503-515.

AIR ENGINEERING

THE HYDRAULIC AIR-COMPRESSOR, A. E. Chodzko. Western Engineering, vol. 8, no. 3, March 1917, pp. 109-113.

THE PHYSICAL PROPERTIES OF AIR IN RELATION TO PRACTICAL PROBLEMS, H. Eisert. The Monthly Journal published by the Engineers' Club of Baltimore, vol. 6, no. 9, March 1917, pp. 209-228.

COMPRESSED AIR FOR COAL-CUTTERS. The Iron and Coal Trades Review, vol. 94, no. 2556, February 23, 1917, p. 218.

AIR DRYING, Carl Hering. Metallurgical and Chemical Engineering, vol. 16, no. 4, February 15, 1917, pp. 187-190.

AUTOMOBILES

HYDRAULIC TRANSMISSION, F. Leigh Martineau. The Auto, vol. 22, no. 7/841, February 16, 1917, pp. 118-119.

DRAW BAR PULL, R. A. M. The Autocar, vol. 38, no. 1, 113, February 17, 1917, pp. 159-160.

CEMENT

THE CEMENT GUN IN OVEN REPAIRS, H. V. Patterson. Coal Age, vol. 11, no. 8, February 24, 1917, pp 348-349.

CONVENTIONS

BOOSTER MEETING FOR FORGERS' CONVENTION. The American Drop Forger, vol. 3, no. 2, February 1917, pp. 37-38.

COOLING TOWERS

COOLING TOWERS AND PONDS, Charles L. Hubbard. Steam, vol. 19, no. 3, March 1917, pp. 68-70.

DRYING

CONTINUOUS MECHANICAL DRYING MACHINE. Engineering, vol. 103, no. 2665, January 26, 1917, pp. 77-79, 6 figs.

ELEVATORS

FLOATING PNEUMATIC GRAIN ELEVATORS. Engineering, vol. 103, no. 2667, February 9, 1917, pp. 121-124, 19 figs.

ENGINEERING MATERIALS

BORONIZED METALS: SOME MINUTE ASPECTS, James Scott. The Metal Industry, vol. 15, no. 3, March 1917.

ALUMINUM ROLLING MILL PRACTICE, George Lyon, Jr. The Metal Industry, vol. 15, no. 3, March 1917, pp. 109-111.

SUR L'EMPLOI DE LA BAUXITE COMME MATIÈRE REFRACTAIRE, Louis le Chatelier. Revue de Métallurgie, vol. 13, no. 5, September-October, 1916, pp. 319-323.

L'ETAT ACTUEL DE LA FABRICATION DES BRIQUES DE SILICE, Henry Le Chatelier. Revue de Métallurgie, vol. 13, no. 5, September-October, 1916, pp. 324-330
Present state of silica brick manufacture.

EFFET DU RECUIT SUR LES PIÈCES EN ACIER SURCHAUFFÉ. REV. DE LA SOC. RUSSE DE MÉTAL, I, 31-37, 1916, S. Smolensky (II-2 et VIII-I). Revue de Métallurgie, vol. 13, no. 5, September-October, 1916, pp. 211-212.
The influence of annealing on overheated steel.

ALTERNATING STRESS EXPERIMENTS, William Mason. Engineering, vol. 103, no. 2669, February 23, 1917, pp. 187-190.

THE PROPERTIES OF BRONZES FOR MECHANICAL PURPOSES, H. S. Gulick. The Foundry, vol. 45, no. 2 (whole no. 294), February 1917, pp. 68-69.

RATIONALITY IN PHYSICAL AND METALLOGRAPHIC TESTING, Lieut. K. F. Smith. Journal of the American Society of Naval Engineers, vol. 29, no. 1, February 1917, pp. 63-87.

MECHANICAL DEFORMATIONS IN METALS, B. D. Ballantine. Machinery, vol. 23, no. 7, March 1917, pp. 576-577, 2 figs.

DATA FOR SHEARING STEEL AND OTHER METALS, W. Trinks. The Blast Furnace and Steel Plant, vol. 5, no. 3, March 1917, pp. 95-97, 2 figs.

DIE VERHINDERUNG DES RÖSTENS DER EISENEINLÄGEN IM EISENBETON, Bruno Zschokke. Schweizerische Bauzeitung, vol. 69, no. 6, February 1917, pp. 57-64.
Prevention of rusting of iron elements in reinforced concrete.

THE MECHANICAL TESTING OF CAST IRON. The Iron Age, vol. 99, no. 8, February 22, 1917, pp. 484-485.

GIVING METALS A RUST-PROOFING TREATMENT. The Iron Age, vol. 99, no. 10, March 8, 1917, pp. 587-589.

BIBLIOGRAPHY

SOME RELATIONS BETWEEN THE MAGNETIC AND THE MECHANICAL PROPERTIES OF STEEL AND OF NICKEL, S. R. Williams. Journal of The Cleveland Engineering Society, vol. 9, no. 4, January 1917, pp. 184-201, 10 figs.

A BIBLIOGRAPHY OF ALLOYS: BINARY, TERNARY AND QUATERNARY SYSTEMS WHOSE EQUILIBRIA HAVE BEEN INVESTIGATED, Clarence Estes. Metallurgical and Chemical Engineering, vol. 16, no. 5, March 1, 1917, pp. 273-282.

FIRE PREVENTION

FIRE PREVENTION AND EXTINCTION, Bernard A. Westbrook. The Journal of the Institution of Mechanical Engineers, no. 2, February 1917, pp. 865-878.

FOUNDRY

CASTING STEEL WHEELS FOR MOTOR TRUCKS. The Iron Trade Review, vol. 60, no. 8, February 22, 1917, pp. 465-471, 14 figs.

HOW HEAVY AMMONIA STILLS ARE MOLDED. The Foundry, vol. 45, no. 295, March 1917, pp. 107-109.
A novel method of molding enabled the Hoovens-Ovens-Rentschler Co. to double production on a limited floor area.

WHAT FOUNDRYMEN CAN DO TO PREVENT HOT BOXES, Russell R. Clarke. The Foundry, vol. 45, no. 295, March 1917, pp. 111-114.

THE SEASONING OF CASTINGS, Richard Moldenke. The Foundry, vol. 45, no. 295, March 1917, pp. 96-97.

ESSENTIAL FACTORS IN FOUNDRY COST ACCOUNTING, Clinton H. Scovell. The Foundry, vol. 45, no. 295, March 1917, pp. 90-93.

IMPROVEMENT IN METHOD OF CASTING INGOTS, B. C. Cushing. Bulletin of the American Railway Engineering Association, vol. 18, no. 195, March 1917, pp. 1075-1079.

CASTING HIGH-SPEED STEEL TOOLS TO SHAPE. American Machinist, vol. 46, no. 7, February 15, 1917, pp. 285-287.

FUEL AND FIRING

FUEL ECONOMY AND UTILIZATION OF COAL, William A. Bone. Proceedings of The South Wales Institute of Engineers, vol. 32, no. 3, January 23, 1917, pp. 373-409, 8 figs.

* Abstracted in the Engineering Survey in this issue.

The Utilization of Waste Products and of Low-Grade Fuels for Power-Generation, John B. C. Kershaw. Metallurgical and Chemical Engineering, vol. 16, no. 4, February 15, 1917, pp. 229-232.

Pennsylvania Commission Reports on the Increased Cost of Coal. Coal Age, vol. 11, no. 8, February 24, 1917, pp. 354-356.

Liquid Fuels for Heating Furnaces, George F. Pearce. Machinery, vol. 23, no. 7, March 1917, pp. 615-616.

Fuel Cost in Public Utilities, W. S. Barstow. The Gas Age, vol. 39, no. 5, March 1, 1917, p. 237.

Engineering Phases of Smoke Abatement, Osborne Monnett. Proceedings of the Engineers' Society of Western Pennsylvania, vol. 32, no. 9, December 1916, pp. 772-778, 4 figs.

Coal and Ashes Handling and Storage—II, Henry J. Edsall. Practical Engineer, vol. 21, no. 5, March 1, 1917, pp. 225-228, 4 figs.

Scientific Methods of Coal Buying, John B. C. Kershaw. Coal Age, vol. 11, nos. 8-10, February 24-March 10, 1917, pp. 350-352, 387-390 (4 figs.), 424-426.

FURNACES

Petit four fonctionnant aux températures très élevées. Rev. de la Soc. Russe de Métal., 1710 (1915), Leon Dlougatch. Revue de Métallurgie, vol. 13, no. 5, September-October, 1916, p. 226.
Small furnace running at very high temperatures.

GAS ENGINEERING

Variation de la chaleur spécifique des gaz avec la pression, Silvio Lussana. Annales de Physique, tome 6, series 9, November-December, 1916, pp. 344-356.
Variation of the specific heat of a gas with the pressure.

The Limits of Inflammability of Gaseous Mixtures, W. M. Thornton. Philosophical Magazine and Journal of Science, vol. 33, no. 194, February 1917, pp. 190-196, 4 tables.

Measurement of the Calorific Power of Gas. Gas Journal, vol. 137, no. 2803, January 30, 1917, pp. 202-206, 1 fig.

Dry-hot vs. Cold-wet Furnace Gas Cleaning, Linn Bradley, H. D. Egbert, and W. W. Strong. The Blast Furnace and Steel Plant, vol. 5, no. 3, March 1917, pp. 104-109, 5 figs.

Directions for Using the Gas Analysis Apparatus, Lieut.-Com. W. T. Conn, Jr. Journal of the American Society of Naval Engineers, vol. 29, no. 1, February 1917, pp. 36-47.

HEAT TREATMENT

Heat-Treating Plant of the New Process Gear Corporation—I, E. A. Suverkrop. American Machinist, vol. 46, no. 10, March 8, 1917, pp. 397-401.

HEATING AND VENTILATION

Heating and Ventilating Private Dwelling Houses, C. T. Alfred Hanssen. The Society of Engineers (Inc.), vol. 7, no. 11, November 1916, pp. 189-214.

Relative Economy of Heating by Steam at Different Pressures, A. Bement. The Heating & Ventilating Magazine, vol. 14, no. 2, February 1917, pp. 27-29.

Combined Steam Heating and Electric Generating Plants, Byron T. Gifford. The Electric Journal, vol. 14, no. 3, March 1917, pp. 101-102.

HOISTING AND CONVEYING

Endless-Rope Haulage at the Works of the Oakbank Oil Co., Ltd. The Iron & Coal Trades Review, vol. 94, no. 2555, February 16, 1917, p. 190.

The "Peters" High-Purchase Gear. Engineering, vol. 103, no. 2668, February 16, 1917, pp. 149-150.

The Stamper Patent Loading Device. Motor Traction, vol. 24, no. 621, January 24, 1917, p. 61, 2 figs.

Crane Extension to Reach Adjoining Bays. The American Drop Forger, vol. 3, no. 2, February 1917, p. 46, 1 fig.
Swinging a jib below the crane bridge to reach sections where overhead cranes would be superfluous most of the time. Bettering operator's viewpoint and enhancing safety.

HYDRAULICS

A New Electrical Method for Testing Water, C. A. Eastwood and C. C. Brown. Journal of Electricity, vol. 38, no. 4, February 15, 1917, pp. 113-115, 1 fig.

Some Notes on Stream Flow, G. C. Brown. The Cornell Civil Engineer, vol. 25, no. 4, January 1917, pp. 161-169.

Water Research. The Engineer, vol. 123, no. 3189, February 9, 1917, pp. 128-130, 5 figs.

Les Machines Hydrauliques a l'Exposition Nationale Suisse de Berne, en 1914, R. Neeser. Bulletin Technique de la Suisse Romande, vol. 43, no. 3, February 10, 1917, pp. 25-29.
Hydraulic machinery at the Berne exposition in 1914.

Factors Affecting Costs of Structural Steel Shop Work, E. W. Pittman. Proceedings of The Engineers' Society of Western Pennsylvania, vol. 32, no. 9, December 1916, pp. 739-743.

Régularisation du régime des cours d'eau utilisés à la production de l'énergie hydro-électrique, Paul Levy Salvador. Revue Générale de l'Electricité, vol. 1, no. 7, February 17, 1917, pp. 253-266.
Control of streams used for the production of hydro-electric energy.

INTERNAL-COMBUSTION ENGINES

Diesel Engine Plants. Main and Auxiliary Equipment. Piping System Highly Important and Carefully Arranged. Novel Operating Conditions, M. Wm. Ehrlich. National Engineer, vol. 2k, no. 3, March 1917, pp. 87-91.

† The Fuel Problem Solved, E. B. Blakely. Motor Boating, vol. 19, no. 1, January 1917, pp. 25 and 56-58, 2 figs.

New Rotary Valve Engine Design, The Automobile, vol. 36, no. 8, February 22, 1917, p. 412, 1 fig.

A Standard of Carbureter Performance, O. C. Berry. S. A. E. Bulletin, vol. 11, no. 5, February 1917, pp. 556-564, 5 figs.

LUBRICATION

Straight Mineral Oil Versus Compound Oil for the Bearings of Marine Engines Not Having Forced Lubrication, Lieut. (J. G.) J. L. Kaufman. Journal of the American Society of Naval Engineers, vol. 29, no. 1, February 1917, pp. 48-62.

MACHINE PARTS

Service Tests of Steel Springs, Geo. T. Glover. Railway Mechanical Engineer, vol. 91, no. 3, March 1917, pp. 124-5.

Investigation of Shafting Failures and Engine Vibration on Vessels of the Louisiana Class, Ernest N. Janson and Lieut.-Commdr. J. O. Richardson. Journal of the American Society of Naval Engineers, vol. 29, no. 1, February 1917, pp. 1-34.

Internal Bevel Gearing, Reginald Trautschold. Machinery, vol. 23, no. 7, March 1917, pp. 611-614, 5 figs.

Calculating Change Gears for Module Pitches, James Farmer. Machinery, vol. 9, no. 230, February 1917, p. 580.

MACHINE SHOP

Equipment for Handling Heavy Pressings, Charles C. Lynde. The American Drop Forger, vol. 3, no. 2, February 1917, pp. 54-57, 4 figs.

Notes on Screw Gauges, R. E. B. Crompton. The Automobile Engineer, vol. 7, no. 99, February 1917, pp. 35-37.

Lubrication of Cutting Tools—III, Edward K. Hammond. Machinery, vol. 23, no. 7, March 1917, pp. 595-607, 17 figs.

Gaging and Inspecting Threads—II, Douglas T. Hamilton. Machinery, vol. 23, no. 7, March 1917, pp. 581-586, 18 figs.

Manufacture of Steel Balls—I, Edward K. Hammond. Machinery, vol. 23, no. 7, March 1917, pp. 563-570, 17 figs.

Martelage forgeage et laminage, Georges Charpy. Le Génie Civil, vol. 70 no. 7, February 17, 1917, pp. 109-113.
Drop Forging and Rolling.

Precision Grinding, J. B. Murphy. American Machinist, vol. 46, no. 8, February 22, 1917, pp. 313-314.

Manufacturing Methods Used in Toolroom. Automobile Jigs and Fixtures Produced Largely by Machine Operators at Enterprise Tool Company Instead of by Tool Makers. The Iron Age, vol. 99, no. 9, March 1, 1917, pp. 525-527.

A Suggested Modification of the Whitworth Screw Thread, W. C. Unwin. Engineering, vol. 103, no. 2668, February 16, 1917, pp. 158-159.

Unification des filetages. Bulletin de la Société D'Encouragement pour l'Industrie Nationale, 115 année, tome 126, no. 6, November-December 1916, pp. 383-388.
Adoption of standard screw threads by the French Post Office, Telegraphs and Telephones.

MACHINE TOOLS

Electric-Driven Herringbone-Gear Planer. American Machinist, vol. 46, no. 7, February 15, 1917, pp. 265-267.

Automatic and Semi-Automatic Machine Tools, C. Warren Boulton. The Journal of the Institution of Mechanical Engineers, no. 2, February 1917, pp. 879-888.

MEASUREMENTS

Screw Thread Measurements, Arthur Brooker. Engineering, vol. 103, no. 2666, February 2, 1917, pp. 113-116, 13 figs.

MECHANICS

Olsen's Rule. The Shipbuilder, vol. 15, no. 76, December 1916, pp. 209-211.

Dynamic Reaction of the Connecting Rod, Walter Rautenstrauch. American Machinist, vol. 46, no. 7, February 15, 1917, pp. 281-284.

METRIC SYSTEM

The Adoption of the Metric System in the United States. The Scientific Monthly, vol. 4, no. 3, March 1917, pp. 193-219.
- The Metric System from the Standpoint of Electrical Engineering, Arthur E. Kennelly, p. 193.
- The Metric System from the Pan-American Standpoint, William C. Wells, p. 196.
- The Metric System in Every-Day Life, H. V. Arny, p. 202.
- The Metric System from the Standpoint of the Wholesale Grocers and Canning Industry, Fred R. Drake, p. 206.
- Wholesale Druggists and the Metric System, Adolph W. Miller, p. 210.
- The International Language of Weights and Measures, George F. Kunz, p. 215.

MUNITIONS

American Industrial Progress as Revealed by War Orders, Earle Buckingham. American Machinist, vol. 46, no. 8, February 22, 1917, pp. 315-321.

Percussion Fuse Production With Female Labor Prominent. (Staff Article) Canadian Machinery and Manufacturing News, vol. 17, no. 10, March 8, 1917, pp. 233-239.

Aids to Production in a Munitions Plant. The Iron Trade Review, vol. 60, no. 9, March 1, 1917, pp. 511-515, 10 figs.
Successful Shrapnel Manufacture, Chester L. Lucas. Machinery, vol. 23, no. 7, March 1917, pp. 571-574, 8 figs.

Shop Inspection Routine in 18 pdr. H.E. Shell Production, A. F. Menzies. Canadian Machinery & Manufacturing News, vol. 17, no 10, March 1917, pp. 202-206.

Female Labor on 8 ins. High Explosive Shell Machining. (Staff Article). Canadian Machinery and Manufacturing News, vol. 17, no. 10, March 8, 1917, pp. 207-214.

Shrapnel Shell Manufacture. Canadian Machinery and Manufacturing News, vol. 17, no. 10, March 8, 1917, pp. 241-246.

Machining 9.2 ins. H. E. Shell in a Structural Steel Plant. (Staff Article.) Canadian Machinery and Manufacturing News, vol. 17, no. 10, March 8, 1917, pp. 195-201.

Manufacturing Brass Cartridge Cases for Shrapnel and High Explosive Shell. (Staff Article.) Canadian Machinery and Manufacturing News, vol. 17, no. 10, March 8, 1917, pp. 217-223.

United States Munitions. The 3-in. Common Shrapnel. American Machinist, vol. 46, no. 9, March 1, 1917, pp. 353-377.

United States Munitions. The Springfield Model 1903 Service Rifle. Making the Guard—I and II. American Machinist, vol. 46, nos. 7 and 8, February 15 and 22, 1917, pp. 287-293 and 333-338.
Floor Plate—II: Floor Plate Catch, Magazine Spring, Cutoff and Follower. American Machinist, vol. 46, no. 10, March 8, 1917, pp. 415-426.

RAILWAY ENGINEERING

The Chilled Iron Car Wheel. Official Proceedings of Canadian Railway Club, vol. 16, no. 2, February 1917, pp. 14-42.

† Southern Duplex Locomotives. Railway Mechanical Engineer, vol. 91, no. 3, March 1917, pp. 121-123.

Eighty-Five Ton Hopper Car for the Pennsylvania. Railway Age Gazette, vol. 62, no. 10, March 9, 1917, pp. 391-393.

Resistance of Passenger Train Equipment, E. C. Schmidt and H. H. Dunn. Railway Age Gazette, vol. 62, no. 10, March 9, 1917, pp. 407-409.

Side Bearing Location, Lewis K. Sillcox. Railway Review, vol. 60, no. 6, February 10, 1917, pp. 198-200, 3 figs.

Eiserne Personenwagen in Deutschland, W. Rudolph. Stahl & Eisen, 37 Jahrgang, no. 1, January 4, 1917, pp. 9-15, 8 figs.
Iron passenger cars in Germany.

The Chilled Iron Car Wheel in Steam Railroad Service, G. W. Lyndon. Canadian Machinery and Manufacturing News, vol. 17, no. 8, February 22, 1917, pp. 145-149, 9 figs.

Motive Power of the Missouri, Kansas & Texas Ry., J. W. Kendrick. Railway Review, vol. 60, no. 8, February 24, 1917, pp. 272-274.

Temperature-Pressure Changes in Blowing Off and Refilling Locomotive Boilers. Railway Review, vol. 60, no. 8, February 24, 1917, p. 258, 1 fig.

Eighty-five Ton Hopper Gondola Car for the Pennsylvania Railroad. Railway Review, vol. 60, no. 10, March 10, 1917, pp. 323-332.

The Quick Bend Test of Rails as a Substitute for the Drop Test, W. C. Cushing. Bulletin of the American Railway Engineering Association, vol. 18, no. 195, March 1917, pp. 1081-1090.

Induced Interior Transverse Fissures in Heads of Two Types, Dr. P. H. Dudley. Bulletin of the American Railway Engineering Association, vol. 18, no. 195, March 1917, pp. 1055-1063.

The Locomotive Furnace, J. T. Anthony. Official Proceedings of the New York Railroad Club, vol. 27, no. 4, February 16, 1917, pp. 4799-4828.

STEAM ENGINEERING

Accuracy of Steam Flow Records, K. H. Smith. Canadian Engineer, vol. 32, no. 6, February 8, 1917, pp. 130-131.

Boiler-House Operation and Maintenance, with Special Reference to the Rand Power Companies' Plant, T. G. Otley and Verney Pickles. The Journal of the South African Institution of Engineers, vol. 15, no. 6, January 1917, pp. 90-123, 13 figs.

Steam Turbines for Land Purposes. The Engineer, vol. 123, no. 3188, February 2, 1917, pp. 107-108, 5 figs. (The Mechanical Engineer, vol. 39, no. 994, February 9, 1917, pp. 95-98, 5 figs.)

A Rapid Method of Plotting Combined Indicator Diagrams, A. R. Munro. The Engineer, vol. 123, no. 3189, p. 137, 6 figs.

† Water Conditions in the Locomotive Boiler, George L. Fowler. Railway Age Gazette, vol. 62, no. 9, March 2, 1917, pp. 359-362.

† Ford Boiler and Gas Plants, Thomas Wilson. Power, vol. 45, no. 8, February 20, 1917, pp. 239-243.

Bonus Systems in Steam Power Plants, Joseph W. Hays, Combustion Engineer. Steam, vol. 19, no. 3, March 1917, pp. 66-67.

Steam Engine Troubles, H. Hamkens. Power, vol. 45, nos. 9-11: Governors—II, February 27, 1917, pp. 284-288; Releasing Gears, March 6, 1917, pp. 314-316; Wristplates, March 13, 1917, pp. 350-352.

THERMODYNAMICS

The Present Status of the Thermodynamic Properties of Carbon Dioxide, Frederick G. Keyes and Arthur W. Kenney. A. S. R. E. Journal, vol. 3, no. 4, January 1917, pp. 17-43, 8 figs.

Determining Heat Transmission of Compound Walls with Tests on Insulated Steel Car Sections, Arthur J. Wood. A. S. R. E. Journal, vol. 3, no. 4, January 1917, pp. 44-72, 9 figs.

CHARTS

B.T.U. Losses for Various Types of Construction. The Heating and Ventilating Magazine, vol. 14, no. 2, February 1917, p. 59.

Horsepower Required by Triplex Pumps.
Horsepower Reduced by Centrifugal Pumps.
Kilowatt-Hour Consumption for Centrifugal Pumps.
Kilowatt-Hour Consumption for Triplex Pumps.
Electrical Review, vol. 70, no. 7, February 17, 1917, p. 273.

Strength Curves of Copper, Iron and Steel. Machinery, vol. 23, no. 7, March 1917, p. 594.

Specific-Heat Ratio (C_p/C_v) of Vapors and Gases and its Relation to Number of Atoms in Molecule. The Gas Engine, vol. 19, no. 3, March 1917, p. 130.

Equivalent Cost of Coal and Oil as Fuel, R. L. Wales. Power, vol. 45, no. 11, March 13, 1917, pp. 347-348.
Chart to determine relative cost of coal and oil fuel.

The Loss of Coal Through Grates, Carleton W. Hubbard. Power, vol. 45, no. 9, February 27, 1917, pp. 276-279.
Chart to determine loss of coal through grates.

Water in the Ammonia Charge, E. W. Miller. Power, vol. 45, no. 10, March 6, 1917, pp. 312-313.
Diagram for figuring dimensions of dished heads.

Wing Loading and Lift Coefficients. Flight, vol. 9, no. 5, February 1, 1917, pp. 105.

LIBRARY NOTES

From the Libraries of the Four Founder Societies and the United Engineering Society, in the Engineering Societies Building, New York City

Our New Librarian

WE are pleased to announce the appointment of Dr. Harrison W. Craver, until recently librarian of the Carnegie Library in Pittsburgh, to be Director of the combined libraries of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the United Engineering Society.

Dr. Craver was born in Owaneco, Illinois, August 10, 1875. He was educated in the public schools of Carmi, Illinois, and

DR. HARRISON W. CRAVER

Terre Haute, Indiana, and the Rose Polytechnic Institute, from which he was graduated in 1895, having specialized in industrial chemistry. The following year was spent in post-graduate chemical study with Dr. W. A. Noyes. In 1896 he became chemist to Kirkpatrick & Co., Limited, of Pittsburgh, and later to the Shoenberger Steel Co., the Virginia Iron, Coal & Coke Co., and the Duquesne Reduction Co. During this period he acquired a practical knowledge of iron metallurgy, particularly of open-hearth steel manufacture.

In 1900 Dr. Craver first became associated with the Carnegie Library of Pittsburgh, being asked by the librarian, Dr. Edwin H. Anderson, now director of the New York Public Library, to undertake the organization of a technological department. To this work his attention was given until 1908, although interrupted by some returns to metallurgical work. Among these the most important was in 1902, when he became assistant superintendent of the Allegheny Steel Co., then in process of organization, and was placed in charge of their rolling mills. In 1908 he was elected librarian of the Carnegie Library of Pittsburgh, which position he has held since.

Dr. Craver's library experience has been unusually varied. The Technology Department, his first task, was a venture in a field hitherto untried, as no municipal library had attempted to meet the special wants of engineers and manufacturers. The methods of organization and the plan of service adopted have proved the model for the technology departments since inaugurated in most similar institutions in America. He has developed an unusual system of coöperation with the public schools and has been able, through the constant succession of bibliographic publications issued by the Library under his direction, to be of service to libraries and students throughout the world. The bibliographies on engineering subjects have been especially appreciated.

Among librarians his services to the profession have long been recognized. He has been since 1909 a member of the Council of the American Library Association, a member of the Executive Board since 1913, and Chairman of the Finance Committee since 1914. At present he is also First Vice-President of the Association.

Dr. Craver has been a member of the Engineers' Society of Western Pennsylvania since 1900. He was for several years a director of the society and chairman of the publication committee. He is also a member of the American Chemical Society and of the American Association for the Advancement of Science.

Now that the libraries of the four Founder Societies are grouped under one roof, an opportunity occurs to mold them into one all-embracing Engineering Library and to render this of service to the greatest degree to the members of the Societies and the profession generally.

Dr. Craver will be given most cordial support by the Library Board to develop his ideas and bring this all-important problem to a successful issue.

Library Service Bureau

THE Library Service Bureau, conducted by the United Engineering Society, has greatly increased its clientele since its foundation in April 1915. Service has been rendered to correspondents in 239 localities in 45 States in the United States, as is shown on the map here reproduced, and to foreign correspondents in 70 localities in 23 foreign countries. Photostat copies of articles in engineering periodicals have been sent to far-distant Australia, Korea and South Africa. Bibliographical assistance has been given in connection with the unification of railways in Australia, and the revision of the mining laws in that country; the development

of mining in China, Korea and South Africa; the raising of a sunken vessel in Chile; the construction of oil storage tanks in India, and the electrification of railways in Austria. The service is therefore nation-wide and world-wide.

U. E. S. Accessions

Abstracts of Current Decisions on Mines and Mining, reported from May to August 1916. U. S. Bureau of Mines. Bulletin 143. *Washington, 1917.* Purchase.

Allentown, Pa., Mayor's Annual Message, 1916.
——— Report of Superintendent of the Department of Accounts and Finance of the Public Accounts 1916-1917. Gift of City Clerk.

American Foundrymen's Association. Transactions. vol. XXIII. Cleveland, *1915.* Purchase.

Canadian Trade Index. 1916-1918. *Toronto, 1916.* Purchase.

Cellulose. By Cross & Bevan. *London, N. Y., 1916.* Purchase.

Central States Conference on Rail and Water Transportation, Official Proceedings. Dec. 14-15, 1916. Purchase.

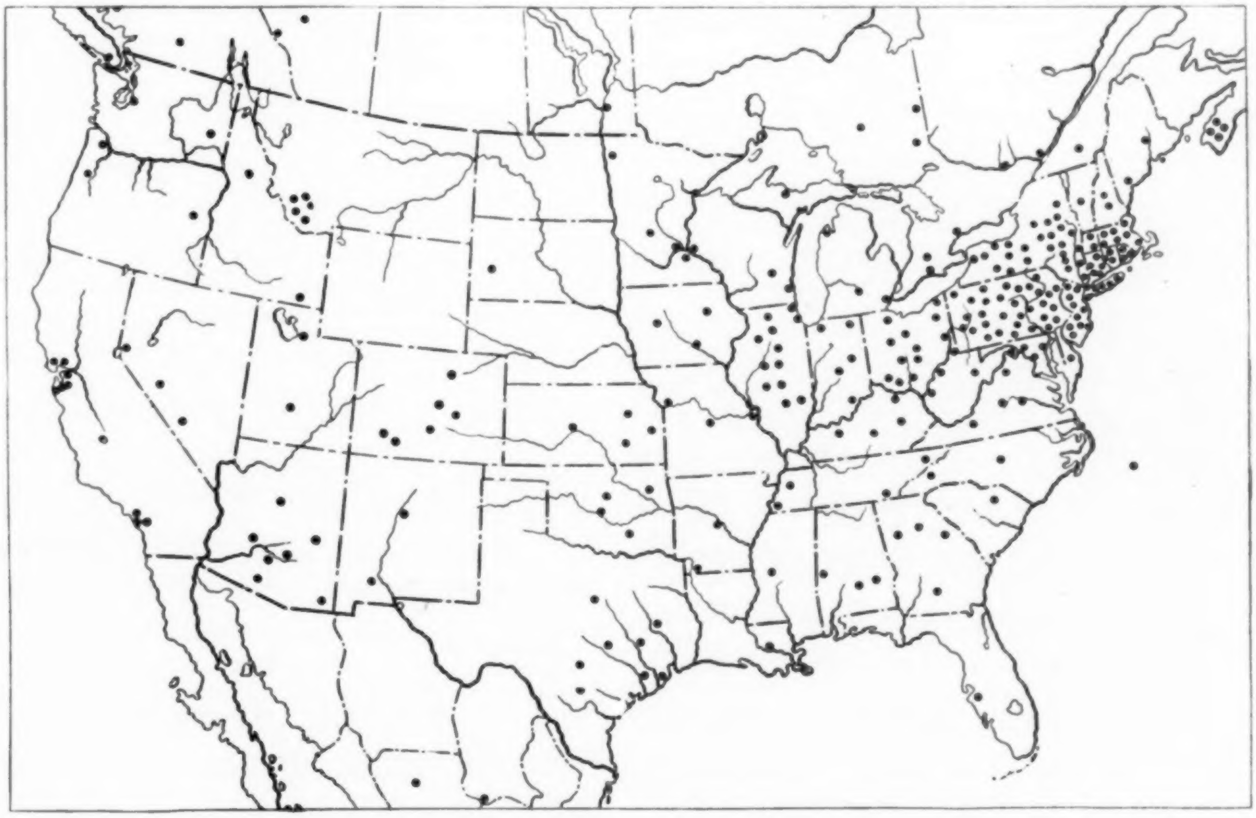
Coal Mine Fatalities in the United States, 1916. By Albert H. Fay. *Washington, 1917.* Purchase.

Cobalt Alloys with Non-Corrosive Properties. Canada. Mines Dept. pub. no. 411. *Ottawa, 1916. Purchase.*

De Beers Consolidated Mines, Ltd. Annual Report, 28th, 1916. *Kimberley, 1916.* Purchase.

The Development of the Steam Engine. By Max Toltz. Gift of W. P. Cutter.

District of Lake St. John, Quebec, Part of. Canada. Geological Survey; Memoir 92. *Ottawa, 1916.* Purchase.



Geographical Distribution of Library Service Bureau Correspondents

American Iron & Steel Institute. Year Book. 1910, 1912-1915. *New York, 1910, 1912-15.* Gift of American Iron & Steel Institute.

American Library Annual, 1915-16. *New York, 1916.* Purchase.

American Railway Engineering Association. Proceedings. vols. 15-17. *Chicago, 1914-16.* Purchase.

American Railway Master Mechanics' Association. Proceedings. vol. XLIX. *Chicago, 1916.* Purchase.

The Ash in North Carolina. Press Bulletin no. 156, N. C. Geological & Economic Survey. *Chapel Hill, 1917.* Purchase.

Bibliography of Fishes. Volume I, Authors' Titles A-K. *New York, 1916.* Purchase.

Bibliography of Recent Literature on Flotation of Ores, January to June 1916. U. S. Bureau of Mines. Technical Paper 135. *Washington, 1917.* Purchase.

A Brief Description of the Physical and Operating Properties of the Subsidiary and Affiliated Companies of the General Gas and Electric Company, May 1915. *New York,* n.d. Gift of Chas. H. Armstrong.

Buyers' Guide for Textile Mills. A handy reference book for buyers of textile mill supplies and equipment. New York, n.d. Gift of Textile World Journal.

By-Product Coke and Gas Ovens for the Recovery of Ammonia, Tar and Benzols. Designed and built by H. Kopers Company. *Pittsburgh,* n.d. Gift of H. W. Nicolson.

Calculus. By H. W. March and H. C. Wolff. *New York, 1917.* Purchase.

Dutch East Indies. Jaarverslag van de Winning, het Vervoer en den Verkoop van Banka-Tin over het Exploitatiejaar 1914. *Batavia, 1916.* Purchase.

Electric Central Station Distribution Systems; their design and construction. Ed. 2. By H. B. Gear and P. F. Williams. *New York, D. Van Nostrand Co., 1916.* Price $3.50. Gift of Publishers.
The first edition of this work was published in 1910, and was based on articles in the Electrical Age. This new edition is due to the rapid progress in the last few years, and has been largely rewritten.
W. P. C.

English and Engineering. A volume of essays for English classes in engineering schools. By Frank Aydelotte. *New York, 1917.* Purchase.

Federal Valuation of the Railroads in the United States. Statement prepared by H. C. Phillips, of the developments in connection with Federal valuation as of February 10, 1917. Gift of Clemens Herschell.

Feldspar in Canada. Canada. Mines Department, pub. no 401. *Ottawa, 1916.* Purchase.

Gas Industry. vols. 11-21. *Buffalo, 1911-12.* Purchase.

Geology of the Country to the South of Kalgoorlie, including the mining centers of Golden Ridge and Feysville, Western Australia. Geological Survey, Bulletin no. 66. *Perth, 1916.* Purchase.

Grandes Voûtes. vol. 6. By Paul Séjourné. *Bourges, 1916.* Purchase.

Graphite, 1916. Gift of Joseph Dixon Crucible Co.

Illinois State Geological Survey. Year Book for 1915. Administrative Report and economic and geological papers. Bulletin no. 33. *Urbana, 1916.* Purchase.

India Rubber, Gutta Percha and Electrical Trades Diary and Year Book, 1917. *London, 1917.* Purchase.

Institution of Civil Engineers. List of Members. 1917. *London, 1917.* Purchase.

Institution of Gas Engineers Transactions, 1916. *London, 1916.* Purchase.

Manchester Association of Engineers. Transactions. 1915-16. *Manchester, 1916.* Purchase.

Manufacturing Costs and Accounts. By A. H. Church. *New York, 1917.* Purchase.

Marine Steam Engine. Ed. 13. By Richard Sennett and H. J. Oram. *London-N.Y., 1916.* Purchase.

Master Car Builders' Association. Proceedings. vol. 50, pt. 1-2. *Chicago, 1916.* Purchase.

Metal Mine Accidents in the United States during calendar year 1915. U. S. Bureau of Mines. Technical Paper 168. *Washington, 1917.* Purchase.

Metropolitan Water Board. Twelfth Report on Research Work by A. C. Houston. *London, 1916.* Purchase.

Motor Cycling Manual. Ed. 3. *London,* n.d. Gift of Frank Gilliland.

National Association of Cotton Manufacturers. Transactions. No. 101. *Boston, 1917.* Purchase.

National Committee for the Prevention of Blindness. Annual Report, 2d, Nov. 1916. *New York, 1916.* Gift of L. Cammen.

National Lamp Works of General Electric Company. Abstract. Bulletin of Nela Research Laboratory Works. *Cleveland, 1917.* Gift of National Lamp. v. 1, no. 2.

New York (City) Department of Water Supply, Gas and Electricity. Communication from Commissioner William Williams to the Board of Estimate and Apportionment, transmitting report of Deputy Commissioner Wilcox upon the Citizens Water Supply Company of Newton, Borough of Queens, Feb. 5, 1917.

——— Report of Delos F. Wilcox, in relation to the Citizens Water Supply Company of Newton, Oct. 7, 1916. Gift of City of New York Department of Water Supply, Gas and Electricity.

New Zealand. Mines Statements for 1915. *Wellington, 1916.* Purchase.

North Carolina and her Natural Resources, some Facts and Figures. Ed. 2. *Raleigh, 1917.* Purchase.

North East Coast Institution of Engineers and Shipbuilders. List of Members, Feb. 1917. *Newcastle-upon-Tyne, 1917.* Purchase.

Oil Investigations in Illinois in 1916. Illinois. State Geological Survey. Bulletin 35. *Urbana, 1917.* Purchase.

Operation of Gas Works. By W. M. Russell. *New York, 1917.* Purchase.

Pennsylvania, Department of Agriculture. Proceedings of the Farmers' Annual Normal Institute. Bulletin 283. *Harrisburg, 1916.* Purchase.

——— Annual Report, 21st. 1915. *Harrisburg, 1916.* Purchase.

Pennsylvania. Department of Mines. Report. Part I—Anthracite, 1915. *Harrisburg, 1916.* Purchase.

Physical Experiments for Engineering Students. By Samuel Sheldon and Erich Hausmann. Part I. Mechanics, Sound, Heat and Light. *New York, D. Van Nostrand Co., 1917.* Price $1.25. Gift of Publishers.

Prepared for sophomore students in the Polytechnic Institute of Brooklyn. There are thirty exercises, covering a course of ninety hours. W. P. C.

Pilot Butte Oil Field. Wyoming State Geologist. Bulletin no. 13. *Cheyenne, 1916.* Purchase.

Preliminary report on the Crystalline and other marbles of Alabama. Alabama Geological Survey. Bulletin no. 18. *University, 1916.* Purchase.

Quarry Accidents in the United States during the calendar year 1915. U. S. Bureau of Mines. Technical Paper 165. *Washington, 1917.* Purchase.

Railway Business Association. A Glimpse at the Works by Frank W. Noxon, Jan. 16, 1917. Purchase.

Railway Problem. Address by Frederick A. Delano, at the annual dinner of the Railway Business Association, Jan. 16, 1917. Purchase.

Refining and Utilization of Georgia Kaolins. U. S. Bureau of Mines. Bulletin 128. *Washington, 1916.* Purchase.

Russian Electrotechnical Commission. Standardization Rules of the American Institute of Electrical Engineers. In Russian. n.p. 1916. Gift of Commission.

Russian Electrotechnical Terminology. By L. D. Tsaxoff. Russian. n.p. 1916. Gift of International Electrotechnical Commission.

Russia. Scientific Committee of the Ministry of Agriculture. Bulletin of Bureau of Agricultural Mechanics. vol. 8, nos. 1-3. n.p. 1916. Gift of Committee.

Seaboard Air Line Railway Company. Annual Statement, 1909-1916. *Portsmouth, Va., 1909-16.* Gift of Company.

The Solution. Address by Alfred P. Thom, at the Annual dinner of the Railway Business Association, Jan. 16, 1917. Purchase.

Some Business Aspects of the Railroad Problem. Address by Walker D. Hines. Annual meeting of the Chamber of Commerce of the U. S. *Washington, D. C., January 31, 1917.* Purchase.

Springfield (Ill.) Insurance Department. Addresses and Papers on Insurance. By R. M. Potts. *Springfield, 1917.* Gift of Insurance Department.

Staffordshire Iron and Steel Institute. Proceedings. vol. 31. *Stourbridge, 1917.* Purchase.

Strength of Ships. By A. J. Murray. *New York. Longmans, Green & Co., 1916.* Price $5.00. Gift of Publisher.

An extensive treatise, largely mathematical, of the strength of beams, columns, shafts, bulkheads, plating, fastenings, rigging, and outboard fittings, plate brackets and rudders, as well as discussions of longitudinal and transverse strength. W. P. C.

System. vols. 11-28. *New York, 1907-1915.* Purchase.

Tables giving the Times of Rising and Setting of the Sun and Moon, 1917 and 1918. Supplement to the American Ephemeris, 1917. *Washington, 1917.* Purchase.

Tentative Valuation by Interstate Commerce Commission, Feb. 14, 1917. Elgin, Joliet & Eastern Railway. Gift of Clemens Herschel.

Thermodynamics of the Steam Engine and Other Heat-engines. Ed. 6. By C. H. Peabody. *New York, 1914.* Purchase.

The Toltz-Lipschutz Acetylene Car Lighting System. By Max Toltz. Gift of W. P. Cutter.

U. S. Bureau of Standards. Circular nos. 14, ed. 5; 16, ed. 4; 30, 35, ed. 2; 38, 3d. 2; 48-49, ed. 2; 51, 52, ed. 2; 53, 54, ed. 2; 55; 57, ed. 2; 59, 60.

——— Scientific Papers. nos. 267-8, 271-6, 278-9; 282-91, 293-5.

——— Technologic papers. nos. 25, 41, 70, 73, 76, 77, 79, 82. Purchase.

U. S. Bureau of Standards. Weights and Measures. 11th Annual Conference. *Washington, 1917.* Gift of Bureau of Standards.

U. S. Interstate Commerce Commission. Valuation in the matter of the property of the Atlanta, Birmingham & Atlantic Railroad Company, Georgia Terminal Company and Alabama Terminal Railroad Company. Hearing, Washington, Jan. 29-Feb. 3, 1917. Gift of Clemens Herschel.

Water Powers of Alabama, Second Report on. Alabama Geological Survey. Bulletin no. 17. *University, 1916.* Purchase.

Western Reserve University. Catalogue, 1916-17. *Cleveland, 1917.* Gift of University.

Who's Who in America. 1903-05. *Chicago, 1905.* Gift of Clemens Herschel.

A.S.M.E. Accessions

Atlantic Deeper Waterway Association. Report of Proceedings of 9th Annual Convention. *Philadelphia, 1917.* Gift of Association.

Detroit (Mich.) Board of Water Commissioners. Annual Report 64th, 1916. *Detroit, 1917.* Gift of Board of Water Commissioners.

Hawaiian Volcano Observatory. Weekly Bulletin. vol. IV, no. 11, 12. *Honolulu, 1916.* Gift of A.S.M.E.

Huddersfield Engineering Society. Journal of Proceedings. 17th session, 1915-16. *Huddersfield, 1916.* Gift of Society.

Inferences Concerning Auroras. By Elihu Thomson. Reprinted from the Proceedings of the National Academy of Sciences, vol. 3, Jan. 1917. Gift of A.S.M.E.

Johnson's Steam Vessels of the Atlantic Coast, 1917. New York, Eads Johnson Publishing Co., 1917. Price $5.00. Gift of Eads Johnson.

This handy volume contains a list of the steam vessels of American registry on the Atlantic Coast. The main facts are given in the list by companies or owners, an alphabetical index being furnished. W. P. C.

Mayor's Committee on Unemployment. Planning Public expenditures to compensate for decreased private employment during business depressions. Extension of an address by John R. Shillady. *New York City, 1916.* Gift to Mayor's Committee on Unemployment.

National Association of State Universities in the United States of America. Transactions and Proceedings. vol. 14, 1916. *Burlington, 1916.* Gift of A.S.M.E.

National Marine Engineers' Beneficial Association, Journal of Proceedings. vol. 14, no. 2. *Chicago, 1917.* Gift of Association.

National Rivers and Harbors Congress. Declaration of Principles adopted Dec 8, 1916. Gift of A.S.M.E.

New Garbage Reduction Plant for the City of New York. By Gustave R. Tuska. Paper read before the 23d Annual Convention of American Society of Municipal Improvements at Newark, N. J., Oct. 9-13, 1916. Gift of author.

The Potentiality of Waterways. Address by Joy Morton before the National Rivers and Harbors Congress, 13th Annual Convention, Dec. 1916. Gift of A.S.M.E.

Propriety of River and Harbor Appropriations. Remarks of Gen. Wm. H. Bixby. Before the National Rivers and Harbors Congress, 13th Annual Convention, Dec. 1916. Gift of A.S.M.E.

Relation of Inland Waterways to Naval Efficiency. An Address by Admiral Wm. S. Benson. Before the National Rivers and Harbors Congress, 13th Annual Convention, 1916. Gift of A.S.M.E.

Some Observations on Water Transportation. An address by Gen. Wm. B. Black. Before National Rivers and Harbors Congress, 13th Annual Convention, Dec. 1916. Gift of A.S.M.E.

Story of the Aeroplane. 1917. Gift of the Wright Flying Field, Inc.

TRADE CATALOGUES

Builders Iron Foundry. Providence, R. I.
Bulletin No. 165. The charge for water actually exists whether it is specifically entered on the accounts or not.

Dielectric Mfg. Co. St. Louis, Mo.
Data on dependable insulation.

Fire Detecting Wire Co. New York, N. Y.
Fire Detection. 1916.

Flannery Bolt Co. Pittsburgh, Pa.
Staybolts. February 1917.

Goodrich, B. F. Company. Akron, Ohio.
Motor Trucks of America, vol. 5, 1917.

Hutchison Vapor Heating Corporation. Washington, D. C. System of vapor heating. 1915.

Kitts Manufacturing Co. Oswego, N. Y.
Catalogue No. 12. Steam specialties. 1917.

Monarch Engineering & Manufacturing Co. Baltimore, Md.
Crucible problem solved.

Under-Feed Stoker Company. Chicago, Ill.
Publicity Magazine. February 1917.

Walworth Mfg. Co. New York, N. Y.
Walworth Log. February 1917.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by April 16 in order to appear in the May issue.

CHANGES OF POSITION

Lieut. Philip B. Eaton of the U. S. Coast Guard Cutter "Bear," San Francisco, Cal., is now stationed at the Naval Aeronautic Station, Pensacola, Fla.

Mark E. Smith, until recently affiliated with the Erie City Iron Works, Erie, Pa., as draftsman, has become associated with the Union Iron Works of the same city.

Frederick W. Starr, formerly connected with the Toledo Scale Company, Hartford, Conn., has become identified with the Fisk Rubber Company, Chicopee Falls, Mass.

T. E. Buck, formerly draftsman with the Donora Steel Company, Donora, Pa., has entered the employ of the United Engineering and Foundry Company, Springfield, Ill.

C. W. Hunting, recently vice-president and general manager of the Minneapolis and St. Louis Railroad, Minneapolis, Minn., has been elected president of the Virginian Railway.

James McNaughton, formerly vice-president of the American Locomotive Company, has been made assistant to the president of the Eddystone Munition Corporation, Eddystone, Pa.

Paul A. Fusselman, formerly general shop foreman of the Kansas City Gas Company, Kansas City, Mo., has become associated with the Counties Gas and Electric Company, Ardmore, Pa.

Waldo H. Blackmer has severed his connection with the American Ammunition Company, Worcester, Mass., and has become affiliated with The Harrison Radiator Corporation, Lockport, N. Y.

John R. LeVally, formerly engineer with the Burrell Belting Company, Chicago, Ill., has become affiliated with Armour and Company, Chicago, Ill., in the capacity of assistant chief engineer.

Harold B. Bernard has resigned his position with The Foxboro Company, Foxboro, Mass., to accept the position of mechanical engineer with the Oklahoma Petroleum and Gasoline Company, Tulsa, Okla.

Arthur Driver, formerly chief tool designer, Gray and Davis, Inc., Boston, Mass., has accepted a position with the Canadian Cartridge Company, Ltd., Hamilton, Ont., Canada, in the capacity of mechanical engineer.

C. J. Bacon has resigned his position as assistant engineer of construction with the Illinois Steel Company, South Chicago, Ill., to enter the engineering department of E. I. du Pont de Nemours Company, Wilmington, Del.

Norman L. Baker has become connected with the American Steel Foundries, East St. Louis, Ill., in the capacity of works engineer. He was formerly mechanical engineer with the By-Products Coke Corporation, Chicago, Ill.

George C. Vennum, until recently assistant chief engineer of the Union Electric Light and Power Company, St. Louis, Mo., has assumed the duties of mechanical superintendent of The Douglas Company, Cedar Rapids, Ia.

Harry D. Carter, until recently fuel engineer with Samuel M. Green Company, Springfield, Mass., has become affiliated with the Warner-Klipstein Chemical Company, Inc., South Charleston, W. Va., in the capacity of superintendent.

Robert B. Adams has resigned his position as assistant superintendent of the New England Westinghouse Company, Meriden, Conn., and has accepted a similar position with the King Sewing Machine Company, of Buffalo, N. Y.

Virgil A. Root has accepted a position in the engineering department of Warner and Swasey Company, Cleveland, O. He was formerly connected with the engineering department of the Subers Fabric and Rubber Company, Cleveland, O.

Kenneth I. Tredwell, until recently purchasing agent with The Sentinel Manufacturing Company, New Haven, Conn., has accepted a position on the production engineer's staff of the Winchester Repeating Arms Company of the same city.

Newman Comfort, manager of the Nebraska Division of the Universal Inspection Company of Iowa, Omaha, Neb., has assumed the duties of manager of the Ohio Branch of the National Workmen's Compensation Service Bureau, Cleveland, O.

John C. Hoar has resigned as master mechanic of the Chateaugay Ore and Iron Company, Lyon Mountain, N. Y., and has assumed the duties of general foreman of repair departments of the American Locomotive Company, Schenectady, N. Y.

Wallace H. Martin, until recently instructor of mechanical engineering at the University of Minnesota, Minneapolis, Minn., has become associated with the mechanical engineering department of The Pennsylvania State College, State College, Pa.

Theodore H. Hermanson, formerly superintendent of the Blake and Knowles Works of the Worthington Pump and Machinery Corporation,

East Cambridge, Mass., has assumed the duties of superintendent of the plant of Henry R. Worthington, Harrison, N. J.

George W. Rice, formerly works manager of The Aultman and Taylor Machine Company, Inc., Mansfield, O., has resigned his position and has accepted the position of assistant general factory manager for the Curtiss Aeroplane and Motor Corporation of Buffalo, N. Y.

H. I. Markey has left the hydraulic turbine department of The Wellman-Seaver-Morgan Company of Cleveland, O., and is now connected with the Firestone Tire and Rubber Company, Akron, O., in the special engineering department handling new plant construction.

Monroe R. Hull has resigned his position as chief engineer of the Arizona Copper Company, Ltd., Clifton, Ariz., to accept the position of mechanical engineer for the Sissert Mining Company, Ltd., with general office at London, and will be located at their properties in Russia.

M. William Ehrlich has become associated with the sales force of the Kewanee Boiler Company, with headquarters in New York. He was formerly connected with Hersh and Brother, heating and ventilating contracting engineers of Allentown, Pa., in the capacity of chief engineer.

Wallace L. Newell, formerly with the Westerman Iron Works, Seattle, Wash., is in the employ of the British Columbia Salvage Company, Vancouver, B. C., as engineer in the salvaging of the German S.S. " Sesostris " which went ashore off the west coast of Guatemala some years ago.

ANNOUNCEMENTS

Carl Ehrmann has become associated with the T-B Gasoline Company, Chelsea, Okla.

James Stokoe has accepted a position with the Sinclair Refining Company, Chicago, Ill.

George W. Dunham has been elected a member of the board of governors of the Aero Club of Detroit.

Walter W. Hagerty has accepted a position with The Roessler and Hasslacher Chemical Company, Perth Amboy, N. J.

John J. Swan has been commissioned by the President as a captain of Engineers, in the Engineer Officers' Reserve Corps of the United States Army.

Palmer Collins, assistant superintendent of the South Works of the American Steel and Wire Company, Worcester, Mass., has severed his connection with the company.

Lieutenant Martin A. Doyle, formerly identified with the U. S. Coast Guard Cutter Mohawk, New York, is now stationed at Pensacola, Fla., Coast Guard Cutter Penrose.

Henry D. Sharpe, president of the Brown and Sharpe Manufacturing Company, Providence, R. I., has been elected a director of the New England Telephone and Telegraph Company.

R. B. Sheridan, president of the Allied Machinery Company of America, New York, left on March 2 for a business trip to Spain and France. He will be away for two months or more.

Cass L. Kennicutt, who for many years has been known as one of the foremost experts in water softening, has become associated with The Permutit Company, in charge of the Chicago office.

Clyde C. Elmes, superintendent of the Eddystone Ammunition Corporation, Eddystone, Pa., has been commissioned a captain in the Engineer Officers' Reserve Corps of the United States Army.

William H. Smead, manager of the heating and equipment department of the Austin Company, Bridgeport, Conn., has been transferred to the home office of the company, Cleveland, O., in a similar capacity.

H. Ralph Hadlow, formerly consulting mechanical engineer, Cleveland, O., has become mechanical engineer with The Watson Engineering Company, Cleveland, O., which has been incorporated to carry on the business of Wilbur J. Watson and Company.

George H. Woodroffe has accepted the position of mechanical and metallurgical engineer with The Parkesburg Iron Company, Parkesburg, Pa. He was formerly in the employ of the Philadelphia Steel and Forge Company, Philadelphia, Pa., as superintendent of the forge department.

Rolla C. Carpenter reaches the retiring age at the end of the present college year and will sever his active connection with Cornell University at that time. Professor Carpenter expects to maintain his activities in the fields of engineering investigation and research for several years to come.

Edwin G. Hatch, consulting engineer, of New York, is arranging to have manufactured in this country a large quantity of 5 per cent nickel steel turbine blades for the Victoria Falls and Transvaal Power Company, Ltd., of South Africa, whose plant serves the Rand Gold Mines. These buckets were, previous to the war, manufactured in Germany.

Stewart M. Marshall, formerly chief engineer of the Cambria Steel Company, Johnstown, Pa., and latterly chief engineer for the Southwark Foundry and Machine Company, Philadelphia, Pa., has formed a partnership with Charles Page Perin, to undertake consulting work connected with the iron and steel industry, with offices at 2 Rector Street, New York.

Benjamin F. Wood, for 16 years electrical engineer, Pennsylvania Railroad, and for the past three years vice-president and chief engineer of the United Gas and Electric Engineering Corporation, announces the organization of B. F. Wood, Engineers, Inc., New York. The new firm will investigate, design, construct and supervise engineering works in power development, transmission, railroad electrification, electric railway and lighting systems and industrial plants.

Gustaf Akerlund and George W. Semmes, formerly chief engineer and assistant chief engineer, respectively, of the Standard Gas Power Company, have established a consulting and contracting engineering business under the name of Akerlund and Semmes, with headquarters at 17 Battery Place, New York. The firm will specialize in gas producer equipment for power as well as for metallurgical and ceramic ware furnaces.

E. Howard Reed, vice-president of the Reed and Prince Manufacturing Company, Worcester, Mass., has enlisted for three months' service as an executive at the United States torpedo station, Newport, R. I., with the rank of a lieutenant commander in the United States naval reserve, thereby releasing one or more officers for active sea duty. Mr. Reed, who is rated in class 4, composed of experienced manufacturers, will be attached to the torpedo-making branch of the station.

APPOINTMENTS

Harold L. Green has been appointed resident manager of the Cleveland office of Scovell, Wellington and Company.

John A. Leach has recently been appointed mechanical engineer of the Minneapolis Steel and Machinery Company, Minneapolis, Minn.

William L. Batt, formerly sales engineer with the Hess-Bright Manufacturing Company, Philadelphia, Pa., has been appointed sales manager.

William L. Saunders of New York, chairman of the Ingersoll-Rand Company, has been appointed as Class C director of the New York Federal Reserve Bank.

Edward J. Kearney, secretary and treasurer of the Kearney and Trecker Company, has been appointed a member of the Wisconsin State Board of Industrial Education, by Governor E. L. Philipp.

AUTHORS

J. E. Johnson, Jr., is the author of a book entitled Blast-Furnace Construction in America.

Richard Moldenke has contributed an article entitled The Seasoning of Castings to the March issue of *The Foundry*.

Fred. M. Heidelberg is the author of An Ideal Changehouse, which appears in the March 3 issue of the *Engineering and Mining Journal*.

Percy H. Wilson, consulting engineer, of Philadelphia, has contributed an article entitled, Edison Portland Cement Plant Remodeled, to the March 3 issue of *Engineering Record*.

N. W. Akimoff is now completing a text book on Applied Hydrodynamics, which will be of the same general character and for the same grade of engineers as his recent book on Lagrange's Equations.

THE NEW BOOKS

ALL books received by The Journal will be listed under this heading, generally accompanied by brief descriptive notes. Works of special importance to mechanical engineers will be commented on at length by members and others peculiarly qualified by reason of their experience and training. In this issue are included two comprehensive reviews of recent works in cost accounting.

Cost Accounting and Burden Application

Cost Accounting and Burden Application. By Clinton H. Scovell, A. M. Harvard University; C. P. A. New York and Massachusetts, Assoc. Am.Soc.M.E., etc. Cloth, 5¼ x 7¾ in., xiv + 328 pp. D. Appleton & Co., New York, 1916. $2 net.

The author of this little book is a specialist in industrial accounting. He is of the modern school, recognizing the fact that cost accounts are of no value unless they are properly interpreted and made use of as one of the elements of scientific management. The book is not a systematic treatise, suitable for students, but is a logical discussion of general principles, criticizing the errors in belief of many of the old school of accountants. It should be read by practical accountants who wish to be informed as to the latest and best theory of their profession. Two of the controversial subjects in accounting theory are treated at great length: Interest Charged to Cost, and Methods of Applying Burden. As to the first the author gives a most convincing argument that interest on investment should be considered as a part of factory cost, taking issue with A. Lowes Dickinson, who presents the opposite view in his book Accounting Practice and Procedure. As to burden application, he condemns the percentage on wages, the percentage on labor and material, and the man-hour rate methods, and approves what he calls the "new machine-rate," which is called by most writers the "machine-hour rate." He shows the necessity of checking the burden charged to cost through the machine rate with the actual burden during corresponding periods, and exposes the unsoundness of the theory proposed by A. Hamilton Church in his book on The Proper Distribution of Expense Burden, and his "supplementary rate" by which the total burden during a period is charged to the cost of the goods produced during that period. The author states the correct principle as follows: "Only a part of the total burden is chargeable to the manufacturing cost of the product made during periods of curtailed production, the part chargeable being the same percentage of total burden as the curtailed production is of the total production."

In a footnote Mr. Scovell seems to claim that he was the discoverer of this principle, and states that he made practical application of it in 1911. The present reviewer, however, used it in 1909 in a works with which he was then connected, not suspecting that it was anything new, and in reviewing Mr. Church's book in *The Iron Trade Review* of Feb. 4, 1909, condemned the supplementary rate and advocated charging a machine with the same burden throughout the year, irrespective of the fluctuations of business conditions outside of the shop.

In a chapter on Unearned Burden the author describes the correct method of treating it in these words: "Monthly cost reports show comparatively the amount of unearned burden, indicating the tendency of business conditions. [It may, however, indicate bad shop management, by which some of the machines are unnecessarily idle.] This unearned burden may either be charged off each period to Loss and Gain or a reserve may be accumulated out of profits during busy times to which the unearned burden may be charged during time of business depression." Special chapters are devoted to discussions of Foundry Costs, Textile Costs, Candy Costs and Paper Manufacturing Costs.

In the interest of good English it would be well for the author in his next edition to avoid the use of the word "inventory" (p. 91) in the sense of "materials" or "stores" and confine it to the dictionary meaning, and on page 50 to change "data" to "datum."

William Kent.

Manufacturing Costs and Accounts

Manufacturing Costs and Accounts. By A. Hamilton Church. Cloth, 5¾ x 9in., 452 pp., 139 illustrations and 4 folding plates. McGraw-Hill Book Co., Inc., New York, 1917. $5.

Mr. Church's immediate purpose is to define the "why and wherefore," the mechanism, and the operations of cost accounting, and to make clear the relations of cost accounting to general accounting. His further intent is to enable the cost accountant on the one hand and the general accountant on the other each to understand and appreciate better the importance of the other's work.

He is therefore concerned wholly with the principles of costing, their application under the three methods of expense distribution later defined, and the nature and proper use of factory cost reports. He does not attempt to describe any specific cost-keeping system, and indeed expressly disclaims any intention or desire of so doing.

The province of factory operations in which the cost accountant works, Mr. Church discerns as an intermediate term in the series by which business generally transforms money into goods, goods into sales, sales into cash again. That is, in a merchandizing enterprise we have the cycle

Cash—purchases—sales—accounts receivable—cash.

The function of the general accountant is to record, separate, classify, and summarize all the details of these transformations, using therefor the standard media—the journal and ledger—conveniently subdivided when a large business is to be handled.

In a manufacturing proposition the cycle becomes

Cash—purchases—*factory operations*—sales—accounts receivable—cash.

The cost-accountant's province includes the whole region of these intermediate changes. He must keep with each item of material, labor, and expense therein an account similar to that which the bookkeeper maintains with each customer and item of cash. He should assume control where the general accountant leaves it at the factory gate, maintain it until the finished product is ready for delivery, and connect his records with the main accounts, of which they form a specialized and detailed subdivision.

His peculiar problems arise from the fact that different items of the purchases (i. e., material) may be justly charge-

able with very different fractions of the collateral outlay for services and expense, and may be in very various stages of completion when a balance is to be struck; and the difficulties thus created increase enormously with the diversity of manufactures carried on in the plant.

Mr. Church sets himself the task of describing the art by which these problems are solved, and of outlining approved practice in dealing with the subjects, situations, and transactions met in actual cost-keeping work.

He begins with a survey of the mechanism of accounting and of cost accounting, the elements of cost, and the means for connecting cost with product. He defines three methods of charging direct labor and expense: *A*, by departmental hour-cost; *B*, by hourly burden or percentage of wages; *C*, by scientific machine rates. He distinguishes further three degrees of subdivision of the unit quantity to which cost may be applied—entire departmental output, definite lots, and individual pieces or parts. He recognizes finally two degrees of detail practicable in determining the departmental cost of any unit—i. e., all departmental processes may be lumped as a total, or each process costed separately. He then outlines the processes of costing by each of the three primary methods *A*, *B*, and *C*, and concludes Part I by a discussion of the common problems of waste, scrap, by-products, depreciation of small tools and equipment, and selling expense.

Part II takes up the actual operations of purchase and production, the departmental activities involved, the standard system of accounts as usually necessary and common to all cost work, and the books, forms, blanks, etc., used for records common to all systems. Four chapters out of the twenty-four in this part are devoted to special forms peculiar to the three primary methods of allocating expense already referred to as *A*, *B*, and *C*, and the last three chapters deal with the collecting of departmental costs and general considerations affecting cost keeping. Part III discusses the nature, scope, and preparation of factory reports and returns.

Of the 140 illustrations in the book, about one-fourth are diagrams tracing the relations between accounts, and the course of items of cost in their passage from original entry to the final controlling account. The remainder are typical rulings and printings for the various books, sheets, cards, schedules, and other forms requisite in standard cost-accounting practice as defined by the author.

Mr. Church appears to have achieved his declared purpose to approach his subject from an angle and by a method different from any foregoing attempt, and to present a survey of the general structure of cost accounts free from detailed description of any specific system of cost keeping. It is open to question whether the view he gives is "comparatively simple," or indeed whether any simplicity, even comparative, can be given to such a conspectus. Ready comprehension of his subject matter, and even of his diagrams, seems to presuppose a familiarity with the processes of general accounting and the phenomena of manufacturing that comes only after long experience with more elementary aspects. The book is hardly one for student beginners. On the other hand, no degree of proficiency is likely to be so great as to put a practitioner beyond the capacity for finding interest and profit in the volume. Certainly, mature minds exercised in the problems appearing along the field of contact between factory production and commercial accounting will find in it suggestion, explanation, and direction obtainable, so far as the reviewer knows, nowhere else.

Charles Buxton Going.

Strength of Ships. By Athole J. Murray. 5½ x 8¾ in., 400 pp., 218 diagrams, 3 folding plates and many tables. Longmans, Green & Co., New York, 1916. $5 net.

In this book, which is said to be the first in the English language to be exclusively devoted to the subject, the author has aimed to include all available information in the field of the strength of materials which has a special application to the design of the structure and fittings of vessels, as well as some of the recently published research work of shipbuilders. The thirteen chapters following an introductory section deal respectively with stress, strain, and elasticity; materials of ship construction; beams; columns; shafts; longitudinal strength; transverse strength; watertight bulkheads; strength of plating; fastenings; rigging and outboard fittings; plate brackets; rudders.

The Marine Steam Engine. By the late Richard Sennett, Engineer-in-Chief of the Navy; Fellow of the Royal School of Naval Architecture and Marine Engineering, etc., and Sir Henry J. Oram, K. C. B., F. R. S., Engineer-in-Chief of the Fleet; Engineer Vice-Admiral, etc. Longmans, Green & Co., New York. Thirteenth edition, 1916, 6 x 9 in., ix + 502 pp., 414 illustrations. $6 net.

In the last two editions of this well-known work—first issued in 1882, much matter has been added to the chapters dealing with the steam turbine, the torsion meter, and the internal-combustion engine, to take account of their rapid development and increasing importance in marine engineering.

Electric and Magnetic Measurements. By Charles M. Smith. 5 x 7¾ in., 373 pp., 171 illustrations. The Macmillan Co., New York, 1917. $2.40.

This course, which has been developed from the author's lecture and laboratory notes, presupposes on the part of the student a year's study of general physics and some knowledge of the calculus. The 56 laboratory exercises which are given are so described that particular types of apparatus are not called for unless they happen to be well known and generally available.

Pipe and the Public Welfare. By R. C. McWane. 5 x 7½ in., 165 pp., 77 illustrations. The Stirling Press, New York, 1917. $1.

After a brief historical sketch of the use of pipe from the earliest days, the author describes the methods used in manufacturing cast-iron, wrought-iron, and steel pipe. A third chapter gives much technical and historical information on the deterioration of metal pipe and canvasses the relative merits of the wrought and cast forms. The final chapter, of 21 pages, is devoted to wood-stave pipe.

The John Fritz Medal. Embossed boards, 6 x 9 in., 98 pp., 14 illustrations. Obtainable from the Secretary, John Fritz Medal Board of Award, Engineering Societies Building, New York City. $4.

The John Fritz Medal is a gold medal presented for achievement in applied science as a memorial to the great engineer whose name it bears. The John Fritz Medal Board of Award, appointed by the four great national engineering societies, has published this handsome volume—from the Bartlett Orr Press, giving a history of the medal, the rules governing its award, biographical sketches and portraits of the thirteen medallists, and the names of those who have served on the Board of Directors and the Board of Award from the establishment of the medal, in 1903, to the present.

The Taylor Society announces that its next meeting will be held in Syracuse, N. Y., May 18 and 19.